Generic Payload Verification Plan Instruction Annex Expedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads

International Space Station Program

June 30, 2000

Issue B, Draft 1

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas
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INTERNATIONAL SPACE STATION
GENERIC PAYLOAD VERIFICATION PLAN
INSTRUCTION ANNEX

EXPEDITE THE PROCESSING OF EXPERIMENTS TO SPACE STATION (EXPRESS) RACK PAYLOADS

ISSUE B, DRAFT 1
JUNE 30, 2000

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GENERIC PAYLOAD VERIFICATION PLAN
INSTRUCTION ANNEX

EXPEDITE THE PROCESSING OF EXPERIMENTS
TO SPACE STATION (EXPRESS) RACK PAYLOADS

DR SE46
(SSP 52000–PVP–ERP/IA)
ISSUE B, DRAFT 1

JUNE 30, 2000

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ABSTRACT

This Instruction Annex is developed to complement the Generic Payload Verification Plan (PVP). This document contains the instructions, definitions, guidelines, and cross-reference matrices to clarify and explain the requirements and processes related to the PVP. This document also contains sample forms and plans for use by the Payload Developer (PD).

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SECTION 1, INTRODUCTION

1.1 PURPOSE

This document contains instructions and clarifications regarding the information in SSP 52000-PVP-ERP. This document supplements the PVP, which defines the complete set of verification requirements and activities necessary to ensure compliance with the EXPRESS Rack payload design-to requirements identified in the EXPRESS Rack Payload Interface Definition Document (IDD). It provides instructions and guidelines for creating the unique PVP required to verify interface compatibility and safety of as-built hardware and software for payloads to be placed on board the International Space Station (ISS).

1.2 SCOPE

This document supplements the Generic EXPRESS Rack Payloads PVP, which encompasses the complete set of verification requirements that address safety and interface compatibility of individual EXPRESS Rack payloads. The PVP requirements pertain to all phases of operations, including ascent/descent, on-orbit integration, and on-orbit operations. Included in this document are sets of cross-reference matrices, sample forms, Suitcase Simulator (ScS) verification capabilities, and options for Human Factors/Crew Consensus verification implementation.

1.3 PRECEDENCE

Inconsistencies among ISS payload verification-related documentation shall be resolved by giving precedence in the following top-down order:

A. ISS Concept of Operation and Utilization (COU), Volume 1: Principles, SSP 50011-01

B. ISS Payload Verification Program Plan, SSP 57011

C. EXPRESS Payload Interface Definition Document, SSP 52000-IDD-ERP*

D. Generic Payload Verification Plan (GPVP) for EXPRESS Rack Payloads, SSP 52000-PVP-ERP*

E. Payload-Unique Documentation: Interface Control Documents (ICD), PVPs, and EIAs

*Note: These documents contain the applicable requirements flowed down from the IRD (SSP 57000) and the GPVP (SSP 57010).

Information contained in the Applicable Documents (Section 2, SSP 52000-PVP-ERP) may be repeated in this document. In case of conflict, the applicable document (revision and date specified) will take precedence.

SECTION 2, PAYLOAD VERIFICATION

2.1 PAYLOAD VERIFICATION PROCESS OVERVIEW

The payload verification process consists of a planning phase, an implementation phase, reporting phase, and a certification maintenance phase as shown in Figure 2-1. The planning phase uses as a basis the ISS Generic Payload Verification Program Plan (PVPP), SSP 57011, which establishes the program-level policy for managing the verification of interface compatibility and safety of payloads using ISS accommodations and resources. This EXPRESS rack (ER) PVP identifies the data to be collected by the ER integrator. This data will be used in integrated rack analyses tasks to satisfy the requirements of SSP 57010 and subsequently SSP 57011. A generic set of Verification Requirement Definition Sheet(s) (VRDS) (see Appendix A, SSP 52000-PVP-ERP) establishes verification requirements associated with each payload design-to requirement contained in the applicable ICD. Each VRDS describes what steps must be taken by the PD to verify the payload as-built hardware and software have satisfied the specific ICD requirement. The collection of VRDSs associated with the payload-unique ICD is called the Payload Unique Verification Plan and is a tailored plan to meet the individual needs of the payload. Appendix A of this document correlates the VRDS numbers, titles, methods, and page numbers from Appendix A of SSP 52000-PVP-ERP in a listing matrix for quick reference.

2.1.1 Planning Overview

A generic set of VRDSs (reference SSP 52000-PVP-ERP) provides instructions, definitions, references, guidelines, and due dates for the verification activities associated with each payload design requirement contained in the IDD. The VRDS describes what steps must be taken by the PD to verify the payload hardware and software have satisfied the specific IDD requirement. The collection of VRDSs associated with the IDD in this Generic Payload Verification Plan forms the basis for generating the payload-unique PVP, which is a plan tailored to the individual characteristics of each payload.

2.1.2 Implementation and Reporting Overview

The implementation and reporting phase is the PD’s execution of the payload-unique PVP, which consists of performing the verification as defined in the VRDSs contained in the payload-unique PVP. This phase also covers verification statusing and tracking, data deliverables and schedules, and support of EXPRESS and ISS safety and integration reviews.

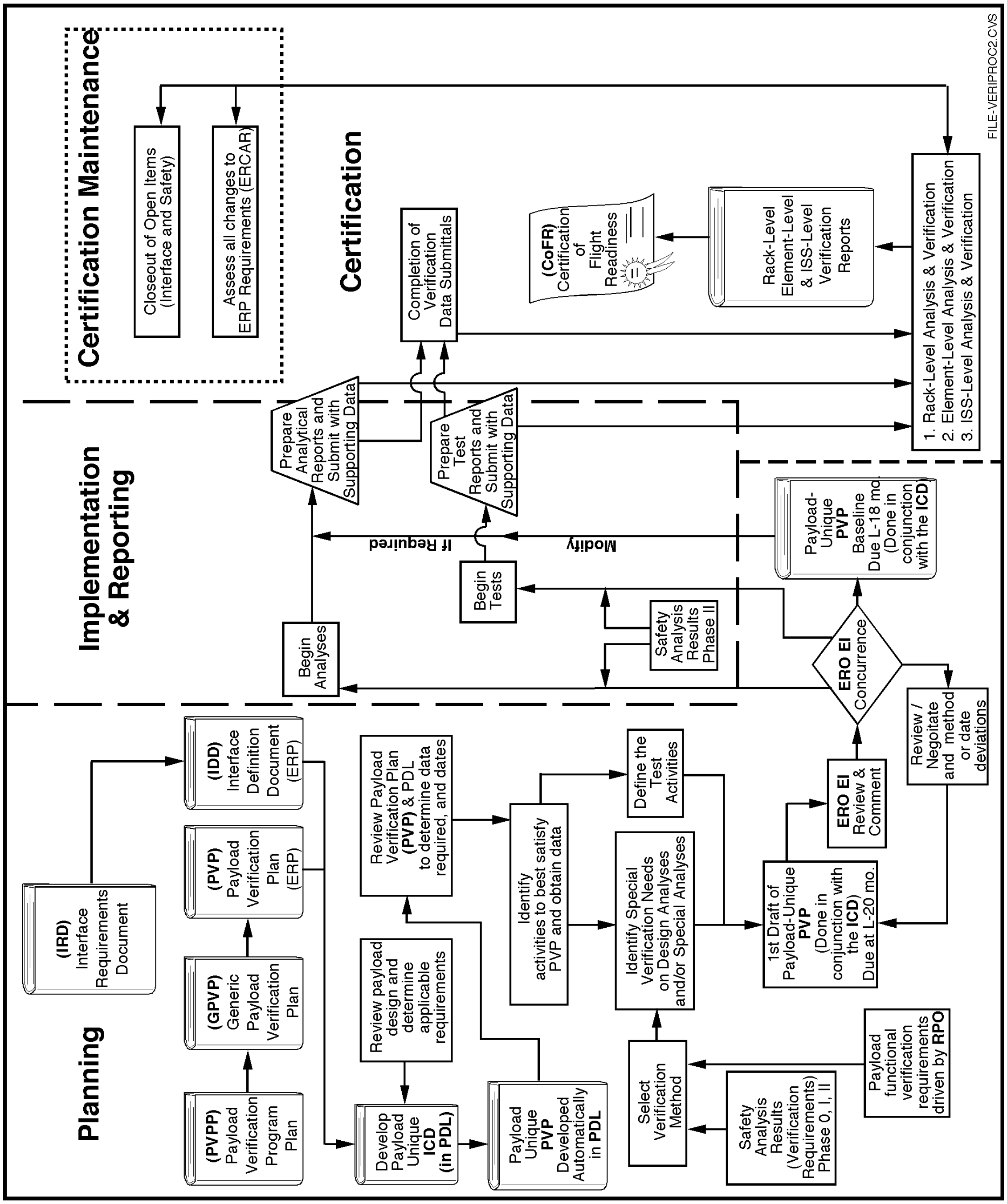

FIGURE 2-1 PAYLOAD VERIFICATION PROCESS

2.1.3 Certification Overview

The certification process includes the signing by the PD of a statement indicating that all of the current requirements and verifications of ISS compatibility, functionality, and safety have been complied with. Any deviations/exceptions from the baselined requirements should have been previously approved. Exception processing is shown in Figure 2-2 and designed in paragraph 2.3.2. Refer to SSP 52054, ISS Payloads Certification of Flight Readiness Implementation Plan Generic, for details of the Certification of Flight Readiness (CoFR) process and SSP XXXXX for specific details on the EXPRESS Rack Office (ERO) CoFR.

2.1.4 Certification Maintenance Overview

Certification maintenance activities occur after signing the CoFR endorsement. Any change to the payload items that are required after the initial certification endorsement must be assessed to ensure that previous verification activities and certification endorsements are not invalidated. Also included here are the assessments of any requirement updates since the original CoFR endorsement. The changes shall be coordinated with the ERO and the ISS Payload Program Office (OZ) for concurrence regarding any required reverification.

2.2 PAYLOAD VERIFICATION PLANNING DETAILS

The process for payload verification planning has been designed and organized for accuracy, completeness, and simplicity. The following sections describe the steps and technical criteria necessary to develop a unique PVP.

2.2.1 Unique PVP Development

The first step in the development of the PVP is to establish a payload-unique ICD. This is performed using the Payload Data Library (PDL) tool. The ICD is created by taking the appropriate IDD and selecting the applicable requirements and establishing any unique requirements or exceptions (waivers, deviations, or exceedances). This ICD becomes the agreement between the PD and ISS representative EXPRESS Payload Integration Manager (EPIM) for requirements associated with interface compatibility and safety that must be satisfied for transportation to, and integration and operation in, the ISS. For each IDD requirement, there is at least one VRDS that describes what has to be accomplished to ensure that the as-built payload hardware and software have met the specified requirement. Appendix A reflects the VRDS-to-IDD requirement reference number correlation in a matrix format. Appendix B reflects the IDD-to-VRDS requirement reference numbers in a matrix format. The VRDS will be described in Section 2.2.3. The ERO uses the PDL to simplify the creation of the PVP.

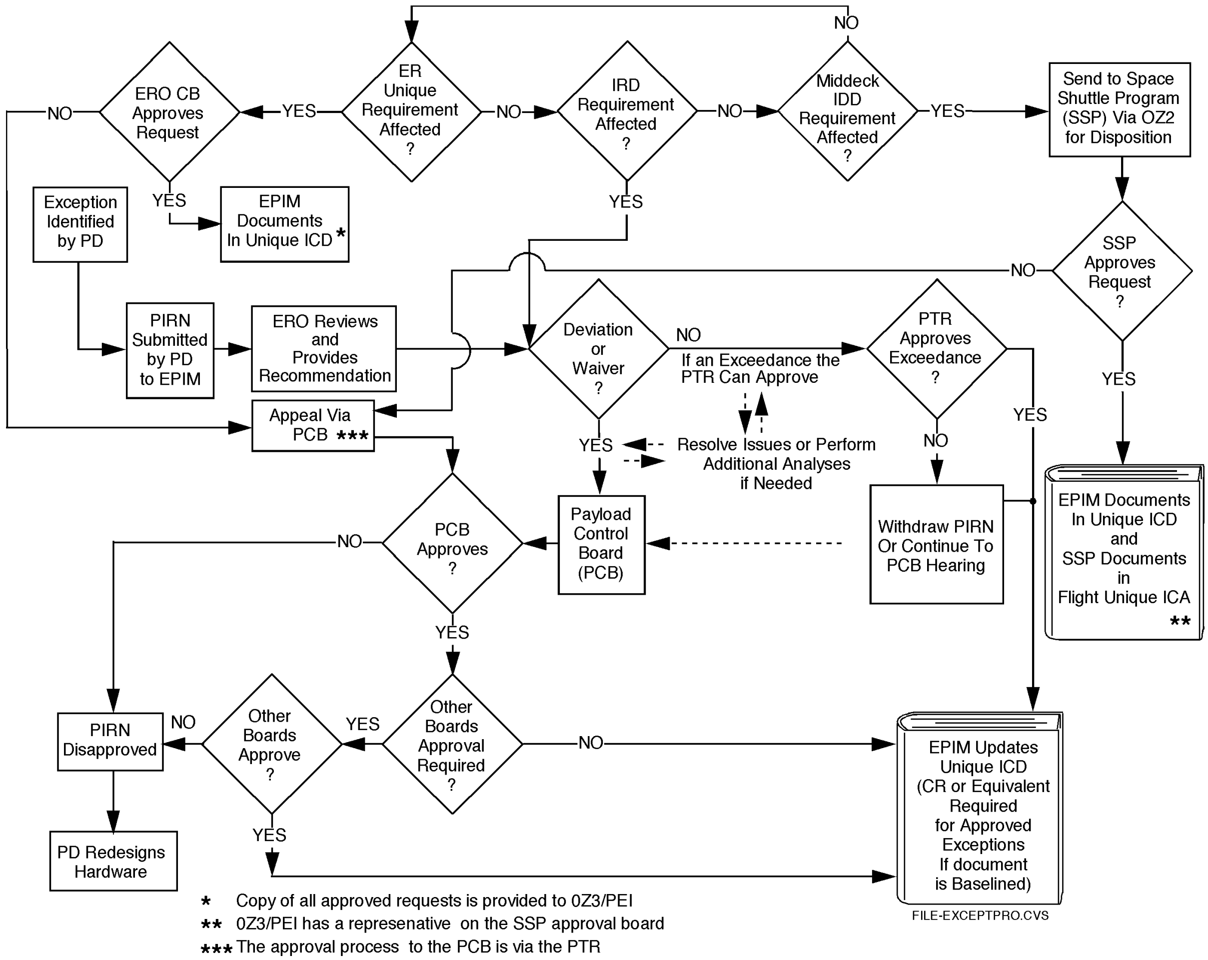

FIGURE 2-2 OVERVIEW OF EXCEPTION PROCESS

The PDL contains the complete set of requirements from the EXPRESS Rack Payloads IDD. Each requirement identified in the IDD has associated with it VRDS(s) which is (are) also contained in a PDL file and linked to the appropriate requirement(s). Applicability of each VRDS is predetermined for each IDD requirement. Therefore, the PVP is developed parallel with the ICD (see Figure 2-3). If an IDD requirement is applicable, then the associated VRDS(s) is (are) also applicable. For unique requirements, exceptions to existing requirements, or additional notes to existing requirements, a provision is made within the PDL to customize a VRDS for the new or altered ICD requirement. This alteration is subject to review and approval by both parties who sign the ICD (i.e., ISS Representative and PD Representative). The collection of applicable VRDSs provided by the PDL becomes the payload-unique PVP.

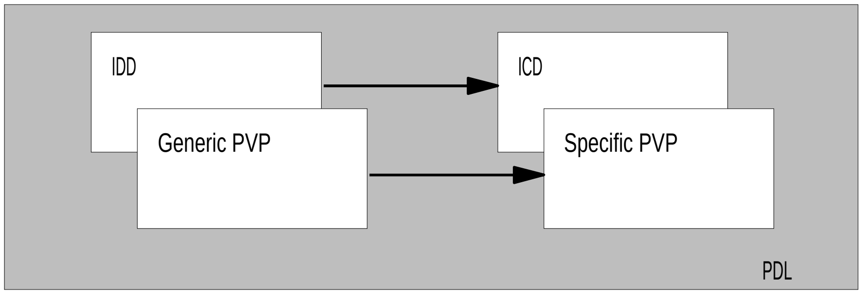

FIGURE 2-3 PVP DEVELOPMENT

2.2.2 Modified/Unique VRDS(s)

Decisions made during the development of the ICD may require modification of standard VRDSs or creation of unique VRDSs to accurately and completely reflect the verification required based on specific needs of an individual payload. Modification of a standard VRDS may take the form of altering the verification method or data submittals or due dates while maintaining the basic verification requirements. A unique VRDS (related to functionality or safety) will be created when no generic VRDS exists which covers a special or unique requirement defined in the ICD, or the generic VRDS is in some way inadequate to verify a special aspect of the payload. Modifications or creation of unique VRDSs require coordination and concurrence among all parties to the governing ICD.

The due dates identified on each VRDS are related to deliveries and product development by other organizations per their requirements in SSP 57010 and SSP 57011. Therefore, noncompliance with any of these items in the VRDSs must be processed as an exception and documented within the PVP in Table 2-I. After the payload-unique PVP is baselined, noncompliances must be handled through the exception process.

If a project verification plan or specification is used as the unique PVP, changes to the methods or submittal dates defined in the VRDSs must also be processed as exceptions and documented in a table in the project verification plan which meets the intent of Table 2-I.

TABLE 2-I VERIFICATION DEVIATION TABLE

VRDS NUMBER	VRDS TITLE	DESCRIPTION OF DEVIATION	REASON FOR DEVIATION
Example ME-003	Payload In-flight Maintenance	Demonstration used in place of analysis	Demonstration is easier and less costly than analysis.
Example EL-012	Remote Power Controllers	Submittal date at L-20 instead of L-22	Hardware will not be ready for testing at L-22.

Proposed changes to the verification method may be more easily approved if the proposed verification method is preferred over (i.e., more stringent than) the method named in the VRDS; however, any VRDS requiring data must be completed in such a way as to supply the specific type of data required.

The order of preference of verification is:

A. Test

B. Analysis

C. Inspection

D. Demonstration

2.2.3 Human Factors-Related Verification Closeout Consideration

An alternate process is available to PDs to close out selected (not all) Human Factors-related VRDSs listed in Appendix G of this plan. The alternate process involves crew/Astronaut Office participation in the evaluation of the PD's hardware and/or software. The process is to have a crew/Astronaut Office representative evaluate the PD-provided flight or flight-like hardware with its associated software and procedures to assess whether operational suitability is met. Based on the evaluation, a Crew Consensus Report will be issued for the PD hardware. The result will serve as data that may be used for closure of PD verification requirements. Crew/Astronaut Office evaluations for this purpose should be planned well in advance and contingency plans developed if the crew/Astronaut Office representative becomes unavailable to complete this activity. For the crew/Astronaut Office repesentative to perform these tasks, it is the PD's responsibility to negotiate and schedule with the Astronaut Office (mailcode CB).

The following paragraphs detail the participation of the crew/Astronaut Office representatives.

2.2.3.1 Crew Evaluation Plan

A. Development Phase

The PD should involve the crew/Astronaut Office representative during the development phase of the hardware to ensure that the hardware is acceptable for safe and effective operation in the ISS. The crew/ Astronaut Office representative approach will be to observe, utilize or operate, and evaluate the functionality of the individual interface features. This will be accomplished in several stages, with early crew/Astronaut Office member exposure to interface features during their development site visits.

B. Execution Phase

Where human factors interfaces requirements are subjective, the PD's hardware will be made available for the crew/Astronaut Office representative to evaluate the operational suitability of these selected human factors interfaces. This can be accomplished incrementally during the crew/Astronaut Office representative site review of the hardware. The process is for the Astronaut Office to be presented the procedure for evaluation, and to have the procedure approved by the Astronaut Office one month prior to the evaluation. The procedure shall define the requirements and the description (picture/drawings) of the interface to be evaluated. The crew/Astronaut Office member will evaluate these interfaces and, if a consensus from the Johnson Space Center (JSC) Astronaut Office is obtained, this evaluation will be used for closure of the verification of the requirement. Appendix G includes a checklist of human factors interfaces acceptable to the Astronaut Office for evaluation sign-off.

2.2.4 The Verification Requirement Definition Sheet

The VRDS form (Figure 2-4) is separated into two parts, the header and the body.

2.2.4.1 VRDS Header

The header is used for identification and tracking purposes and contains:

A. Verification Number

(1) (2) (3)
AA - AA – NNN

(1) Discipline Identifier [2 digits (alpha)]

ST	-	Structural
ME	-	Mechanical
EL	-	Electrical
EM	-	Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)
CD	-	Command and Data Handling
TH	-	Thermal Control
VC	-	Vacuum
GA	-	Gases
EN	-	Environmental
FP	-	Fire Protection
MP	-	Materials and Parts
HF	-	Human Factors

VERIFICATION REQUIREMENT DEFINITION SHEET

Verification Number	Requirement Title	Verification Method
AA-AA-NNN	Example VRDS	A/T/I/D
		Hazard Report Number

Verification Requirement:

The IDD requirement paragraph number and a restatement of the IDD/ICD requirement that must be verified to ensure payload hardware/software interface compatibility and safety (Paragraph Number).

Description of Verification Method:

Instructions and details suggesting how the verification method(s), as identified in the header, should be implemented (what analyses, tests, inspections, or demonstrations are required and implementation details). In addition, any related clarification deemed necessary to further explain what is required will be provided.

Required Verification Data:	*Data Submittal Dates:*
Certificate of Compliance with (COC) the requirement.	L-TBD mo
OR	L-TBD mo
Integrated Rack Analysis Data.	

Description of Reverification Requirements:

Normally the same as “Verification Method,” but if different will be detailed here.

Required Reverification Data:	*Data Submittal Dates:*
Certificate of Compliance (COC) with the requirement.	L-TBD mo
OR	L-TBD mo
Integrated Rack Analysis Data.	

Applicable Documents and Notes:

SSP-52000-IDD-ERP: appropriate subparagraph or identification of other documents.

Note: Relevant information inappropriate for other parts of the VRDS.

FIGURE 2-4 VRDS FORM

SA - Safety
SW - Software and Computers

(2) Configuration Element Identifier [2 digits (alpha)]

MD - Middeck
GS - GSE
ER - EXPRESS Rack
TR - Transportation Rack
MP - MPLM

(3) Numerical Sequence NNN [3 digits (numeric)]

Use all digits - 001, 002, etc. This number represents sequential numbering of VRDSs driven by the discipline identifier and configuration element identifier (Example, ME-TR-002). This is the second VRDS within the mechanical discipline associated with the EXPRESS Transportation Rack.

B. Requirement Title

The requirement title is a category identification of the design-to requirement and is usually taken from the IDD requirement paragraph title where possible. If the verification requirement covers more than one IDD requirement, a general statement will be provided.

C. Verification Method

There are four unique methods of verifying a design requirement: Analysis (A), Test (T), Inspection (I), and Demonstration (D). Each VRDS will identify the required method of verification by indicating the method letter identifier, or a combination of identifiers, if more than one method applies. Also see paragraph 2.2.2.

(1) Analysis

Analysis is the technical evaluation process of using techniques and tools such as mathematical models and computer simulations, historical/design/test data, and other quantitative assessments to calculate characteristics and verify specification compliance. Analysis may be used to verify requirements where established techniques are adequate to yield confidence or where testing is impractical. Included in this category is analysis by similarity whereby a comparison is drawn to items previously verified to the same or more stringent criteria. A special type of analysis for payload experiments that have flown on previous Space Station missions is described in Recertification.

(2) Test

Test is actual operation of equipment, normally instrumented, under simulated conditions or the subjection of equipment to specified environments to measure and record responses in a quantitative manner. Testing is the preferred verification method.

(3) Inspection

Inspection is a physical measurement or visual evaluation of equipment and associated documentation. Inspection may be used to verify construction features, drawing compliance, workmanship, and physical condition. It includes determination of physical dimensions.

(4) Demonstration

Demonstration is the qualitative determination of compliance to requirements by observation during actual operation or simulation under preplanned conditions and guidelines. Usually, no data is taken during a demonstration as is done for a test.

D. Hazard Report Number

This block will only appear in a VRDS that has a related safety requirement. It can be used by the PD as a cross reference to a particular Safety Hazard Report (SHR) number when appropriate.

2.2.4.2 VRDS Body

The body of the VRDS contains the following: a restatement of the applicable IDD design-to requirement; the associated verification method or reverification method description and tasks to be accomplished to verify the requirement has been satisfied; the data that must be generated and delivered as proof of meeting the requirement; and any applicable documentation and notes that may aid in accomplishing the verification.

A. Verification or Reverification Requirement

The IDD requirement paragraph number and a restatement of the IDD/ICD requirement that must be verified to ensure payload hardware/software interface compatibility and safety. If data is different for reverification, it will be defined here.

B. Description of Verification Method

Instructions and details specifying how the verification method(s), as identified in the header, should be implemented (what analyses or tests are required and implementation details). In addition, any related clarification deemed necessary to further explain what is required will be provided. There is nothing different between the verification and reverification for methods.

C. Data Submittal Requirements

Verification and reverification data types are as follows:

(1) Certificate(s) of Compliance (COC) - This data type is a signed certificate(s) (see Appendix E) documenting the completion of all applicable verification requirements identified in the certificate. This COC is submitted by the PD in accordance with the program development schedule. See paragraph 2.3.4 for the requirements for COCs.

(2) Integrated Rack Analyses Data - This data type represents actual payload data required to support an integrated rack complement analysis to be performed by the ERO or data which must be forwarded to other integration organizations. This could include analysis reports, test reports and/or inspection results.

(3) Data Certification - A Data Certification is a memorandum from a PD certifying that the requirements identified on the referenced VRDS have been met and providing the required summary results (see Appendix E). It should also state that the supporting data will be maintained by the PD and provided upon request.

Data submittals for initial verification as well as reverification will be identified by template milestone related delivery dates. A single VRDS may have multiple data submittal types. Note: While all data generated during a PD's verification is not required to be submitted, all data collected must be archived by the PD at the PD site for future reference if needed by the ISS program.

D. Applicable Documents and Notes

This section will be used to identify applicable documentation to assist the developer in accomplishing the specified verification requirements. The references will be detailed with specific paragraphs and/or sections referenced where possible. The specific revision or change identification is located in Section 2 of SSP 52000-PVP-ERP. This part of the VRDS will also contain additional notes and clarification that is inappropriate for other parts of the VRDS.

2.3 PAYLOAD VERIFICATION IMPLEMENTATION

The implementation phase of the verification process executes the payload-specific PVP and the supporting activities to meet programmatic milestones. The major implementation functions are described below.

2.3.1 Verification Method Implementation

The VRDS specifies the method(s) required to that the specified design-to requirement has been met. The engineering methods that must be performed by the PD in verifying the payload hardware/software are Analysis, Test, Inspection, and Demonstration. The PD must provide all resources, support facilities, and equipment necessary to accomplish the tasks associated with each verification requirement and method. The accomplishment of the identified method or combination of methods is the responsibility of the PD and will be scheduled to meet data deliverable requirements and program milestones.

2.3.2 Exceptions/Exception Processing

Any exception to requirements defined in the EXPRESS Rack IDD and/or interfaces defined in the payload-unique ICD and methods/dates specified in the PVP (see paragraph 2.2.2) must be submitted under specific procedures and guidelines to assure proper control, evaluation and approval. This section describes the process by which a Payload-proposed non-compliance to an IDD and/or ICD and/or PVP (paragraph 2.2.2) requirement is processed and dispositioned. These non-compliances are referred to as exceptions. The conditions of the exception will determine further classification as either an Exceedance, Deviation, or Waiver. The terms exceedance, deviation, and waiver are defined in Section 2.3.2.1. The specific requirement or interface excepted, along with a description of the existing condition, and a rationale for acceptance will be documented in the payload-unique ICD. Any proposed exception will require preparation of an Exception/PIRN to the payload-unique ICD. This section describes how exceptions are documented. It also describes how the ERO processes exceptions, and provides for disposition either directly or through appropriate Program Control Boards. An overview of the documentation, approval, and implementation flow of exception requests is provided in Figure 2-2.

2.3.2.1 Definitions

A. Exception

The general term used to identify any payload-proposed departure from specified requirements or interfaces is exception. An exception is further classified as an exceedance, deviation or waiver per the descriptions provided below.

B. Exceedance

An exceedance is a condition that does not comply with a stated IDD and/or requirement, which is identified prior to baselining the payload-unique ICD. It exceeds the defined payload limits but when combined with the remaining payload complement the integrated EXPRESS Rack limits are not exceeded, or it does not impact the performance of the remaining payload complement, and it does not impact EXPRESS Rack or ISS vehicle subsystems performance. The exception can be shown to be acceptable within the framework of the Integrated EXPRESS Rack Verification Compatibility analysis without any unique analysis.

An exceedance can be approved by the ERO CB or the ISSP and PIRN Technical Review (PTR) panel and documented in the payload-unique ICD. Exceedances do not require approval by the CB.

C. Deviation

A deviation is a non-compliance to an IDD and/or ICD requirement, which is identified prior to baselining the payload-unique ICD. It is different from an exceedance in that the defined exception exceeds EXPRESS Rack or ISS Lab/module limits. Additional analysis outside the scope of the EXPRESS Rack Verification Compatibility analysis and/or element analysis cycle or unique operational guidelines or constraints may be needed to approve the exception. Deviations must be approved by a CB.

D. Waiver

A waiver is a condition found in non-compliance to an IDD and/or ICD requirement, which is identified after baselining the payload-unique ICD. Typically this will occur as a result of the final as-built hardware verification program. It may require additional analysis outside of the scope of the EXPRESS Rack Verification Compatibility analysis and/or element analysis cycle or unique operational guidelines or constraints to approve the exception. Waivers must be approved by a CB.

2.3.2.2 Exception Processing Details

All proposed exceptions to IDD and/or ICD and/or PVP requirements are evaluated by the ERO. If these do not affect interfaces external to the Integrated EXPRESS Rack or affect requirements flowed down from higher level document, the exceptions can be approved at the ERO CB.

Exceptions that affect SSP 57000 (IRD) requirements are forwarded from the ERO to be evaluated by the PTR panel . The PTR is part of the ISS Program Payloads office (OZ3). Exceedances may be approved by the PTR and documented in the Unique Payload ICD.

Approval/Disposition signature authority rests with the PTR for those exceptions within their limit of authority.

The Payload Control Board (PCB) has authority to approve exceptions that impact the overall payload complement but do not affect overall ISS requirements (i.e., vehicle).

Exceptions that affect ISS subsystems must be approved by the Development Control Board (DCB). Exceptions that affect Partner modules must be approved by the Multilateral Payload Interface Control Board (MPICB).

Exceptions that affect SSP requirements are forwarded to the SSP by the ERO with coordination by OZ2 representatives.

Evaluation is conducted by reviewers of the appropriate technical or program discipline. Their comments are presented as part of the Exception-PIRN disposition either to the PTR, the PCB, DCB, or the MPICB, according to the criteria discussed above.

2.3.2.2.1 Exception Logging and Traceability

Each payload-unique ICD will identify each exception pertaining to it, and show traceability to its applicable IDD requirement (paragraph). The approved non-compliant condition will be documented in the unique ICD.

2.3.2.2.2 Exceptions Table

Each unique ICD contains a table of exceptions which provides the following information concerning each exception.

The paragraph number of the IDD requirement and the corresponding ICD paragraph number that is proposed to be excepted, the classification (i.e., exceedance, waiver, or deviation) and a unique identifier assigned to each exception. A short description of the exception will be included. The status of the exception will be listed as open until the exception has been approved by the appropriate authority. Once approved the PIRN number and SSCN (or equivalent directive number) will be listed in the status column to document approval.

2.3.2.2.3 Process

Figure 2-2 reflects the process for proposal, evaluation, and disposition of exceptions.

2.3.2.2.3.1 Submittal Requests

The PD will be responsible for submitting any required exception requests. Once the need for an exception is identified, the first step in submitting a request is to provide the pertinent information on an Exception/PIRN form. The Exception/PlRN form and instructions for completion may be obtained from the Payloads Office Documentation Page.

2.3.2.2.3.1.1 Data Submittal Responsibility

The Payload Developer is responsible for providing all data that is needed to evaluate the exception request for approval. Data, in addition to the data submitted with the exception request or contained in the unique ICD, may be required to evaluate the exception. The PD must supply the required additional data before the exception request can be processed.

2.3.2.2.3.1.2 Recording and Maintaining

The book manager (i.e., EPIM) of a payload-unique ICD collects all exception requests. Once a request is submitted, the EPIM, with assistance of ERO technical discipline engineers, verifies that sufficient information has been provided, assigns a preliminary tracking number, and records the necessary information in a database. Additional data may be requested at any time during the exception review process.

2.3.2.2.3.1.3 Control Boards

Exception requests classified as deviations or waivers must be assessed and approved by the appropriate control board(s). The PCB assessed the exception requests, the ERO analysis results, the PEI analysis results, the mandatory evaluators recommendations, and the PTR recommendations. The PCB will either recommend forwarding the exception request to the DCB or the MPICB as appropriate, or direct the PD to modify hardware to meet the IRD requirement in question. PEI and the PD will coordinate the exception request with the DCB and/or MPICB as required to gain approval of the exception. An approved exception request is incorporated into the unique ICD.

2.3.2.2.3.1.4 Safety Exceptions

Exceptions (non-compliances) to safety requirements are handled by the Payload Safety Review Panel (PSRP), with final approval from the Joint Mission Integration Control Board (JMICB) and the Joint Program Review Control Board (JPRCB).

2.3.2.2.3.1.5 Operational Contraints

Most ISS payloads will be on-orbit for more than one stage, and will be included within more than one payload complement. Exceptions that are granted which impact the integrated payload complement must be reassessed during the element analysis cycle for each subsequent increment. Any operational constraints associated with the exception may be modified as required for each subsequent increment and will be documented in the Payloads Operations Guidelines and Constraints document for that increment.

2.3.3 Verification Data Submittal Tracking

PDs will be required to track and status the unique verification plan to closure. This includes tracking the VRDSs and the associated data required for submittal. Periodic verification status may be required to support ISS program integration and safety reviews. Verification tracking and statusing will be performed via the PDL, which is available to PDs for tracking and statusing their detailed verification plans.

The submission dates of data items required for each VRDS are recorded and tracked within the PDL. All categories of data submittal are listed along with the planned dates for when each data submittal is to be completed. As each item is completed by the PD, the record of completion will be entered into the PDL. This action will record the date for later use as a verification completion status at program reviews.

The actual data item is not actually entered into the PDL. The completion dates of these items, however, are recorded in the PDL. Data items must be complete before the COC may be completed.

At the end of the verification process, the PD may print a report of all Data Submittal Items and their completion dates. This report may be attached to a general COC for all items to be signed by the PD authorized representative.

2.3.4 Certificate of Compliance

The COC is the mechanism by which a PD indicates to the appropriate ISS payload integration team that the verification associated with the PVP VRDSs has been accomplished. It is the responsibility of the PD to certify that the PVP has been implemented as specified by the requisite VRDSs. This includes accomplishing all the VRDS requirements by the indicated verification methods, and assuring that the specified data submittal requirements have been met. The COC is a signed statement certifying that the included list of VRDSs has been completed (see Appendix E). The COC shall be signed by the PD and personnel responsible for the performance of the verification methods (i.e., for inspection, quality assurance; for test, test conductor; for analysis, discipline analyst). Note that all Materials and Processes (M&P) verification submittals must have a concurrence from a NASA center materials lab representative for the data to be accepted (ESA and NASDA approved P&P organization concurrences are acceptable). All COCs shall be traceable to the verification methods required, final inspection reports, test procedures, analysis reports, demonstration procedures, etc. For verification tracking and statusing purposes, the VRDSs associated with the COC will be considered closed. It would benefit the PDs to group their closed VRDSs and submit a COC as verification activities are completed. Typical times when verification activities will require statusing are as follows:

A. Prior to hardware ship date - All analyses and most tests (especially those requiring special test facilities/equipment such as Acoustics, EMI, Random Vibration, Microgravity Disturbances, etc.) and most inspections are completed.

B. Completion of physical integration - All remaining tests (limited to functional interface testing) and most inspections are completed.

C. Launch (flight) readiness review - All remaining inspections are complete.

2.3.5 EXPRESS Integration Readiness Review

The determination of integration readiness of the integrated ER is composed of the certification of each sub-rack payload element, the ER and the certification of the integrated ER.

The sub-rack payload certification is a result of:

A. Completion of the verification program.

B. Completion of the flight/ground safety processes.

C. Assembly and check-out of the flight hardware and software before delivery to KSC for integration and testing.

This review process can be tailored to cover two separate cases:

A. Case 1:

The shipment of sub-rack PD hardware for final flight processing and launch in the ER or EXPRESS Transportation Rack (ETR).

B. Case 2:

The shipment of sub-rack PD hardware which only perform integrated testing activities with the ER or Functional Check-Out Unit (FCU) and returned to the PD site for final processing for a mid-deck launch.

The certification from the PD for Case 1 acknowledges the PD for Case 1 the PD has complied with all safety and interface compatibility requirements (including approved exceptions) and the as-built configuration of the hardware and software meets interface requirements and is safe. The certification from the PD for Case 2 acknowledges the PD has complied with the necessary safety and interface compatibility requirements (including approved exceptions) and the configuration of hardware and software meets interface requirements and is safe. The ERO will identify the minimum set of verification requirements needed for testing activities with the ER or FCU. In either of the cases identified above, an EXPRESS Integration Readiness Review (EIRR) will be conducted by the ERO in conjunction with Kennedy Space Center (KSC) and the PD. This review and the associated documentation are discussed in the following paragraphs. A typical agenda is shown in Figure 2-5. This agenda will be tailored to the applicable case identified above. The review results in the signing of the sub-rack payload certification and the identification and acceptance of any open items/open work that are further explained in subsequent paragraphs.

It is acknowledged that some PD organizations may have in place an internal Pre-Ship Review (PSR) or equivalent to assure the PD hardware/software acceptability prior to shipping from the applicable NASA center. If this is the case, the EIRR can be combined with the PD PSR review. The ERO will participate in the PD process concur on the acceptance for shipping forms. The EPIM must be contacted if such a joint review is desired so the necessary coordination can be performed. A joint agenda and co-signed certificates will be developed in advance of this review.

The ERO will make a determination of the signatures required and will inform the responsible individuals of this requirement before the EIRR. The certification shall be signed at the conclusion of the EIRR before the hardware is shipped for physical integration/testing; any hardware removed from the integration flow shall be re-verified when it is returned. Any changes after the EIRR must be submitted via the standard PIRN process. The certification form is shown in Figure 2-6.

2.3.5.1 Open Items and Open Work Lists

Every effort should be made to have all work and tests completed before shipment of the payload elements to KSC. If this cannot be accomplished, the EPIM and the PD must prepare an open items and/or open work list for acceptance by the ERO at the EIRR. These lists are first prepared at the EIRR as a part of the certification and are maintained until closeout of all open items or open work. The PD will be required to periodically report the status of the open items/open work items before shipment, before turnover and during physical integration at KSC.

2.3.5.1.1 Open Items List

The open items list, referenced in Figure 2-7, shall be used by the EPIM and PD to identify any open verification tasks, open hazard reports (flight/ground), open PIRNs, etc. The open items list is then combined with and becomes a part of the certification described above.

TOPIC	PRESENTER
1. Design and Integration Issues resulting from data set review	ERO/EPIM
Integration Requirements versus Accommodations	
EIA and Addenda Status	
ICD/PVP Status	
C&DH Data Set Status	
Configuration Data Set Status	
Assembly and Installation Drawing Status	
2. Open Items List	ERO/EPIM
Verification Critique (as-built flight hardware versus design requirements versus PVP and results) – open verification items	
As-built flight hardware versus safety hazard sheets critique – open flight or ground safety HRs or Action Items	
Design, safety, verification and integration Issues not included	
3. Response to MSFC design and integration issues, open items list and identification of additional items	PD
4. Status and Discussion of:	ERO/EPIM/PD
Exceptions/PIRNs/ECRs	
MUAs (NASA Center Approval)	
Hardware modifications (planned/proposed)	
Open RIDs/DNs from design reviews	
Previous flight on-orbit anomalies	
5. Open Work (reference)	PD
To be done before shipment (reference)	
To be done at KSC (reference)	
Off-line/Pre-turnover by PD (reference)	
On-line by KSC	
6. Support Requirements Data Set Status and Discussion	KSC/LSSM
Confirm resource requirements (QC, technicians, consumables, etc.)	
Confirm shipping address	
Status badging/training of PD personnel	
Status MSDS, PWQ, use authorizations, etc.	
Work time policy compliance	
Tool Control Plan status	
Schedule pre-off-line briefing with LSSM	

FIGURE 2-5 TYPICAL AGENDA FOR EIRR (Sheet 1 of 2)

TOPIC	PRESENTER
7. Technical Requirements Data Set Status File 8/Volume 2, File2/Volume 2, TGHR Table	KSC/LSSM
8. Procedure Status Off-line procedures On-line procedure inputs/KSC Test Procedures	KSC/LSSM
9. Integration Data Package (IDP) Status	ERO/PD/KSC
10. Hardware Inspection Completeness SSP 52000-PVP-ERP verification satisfied by inspection Configuration at EIRR versus flight configuration Note: This is only applicable if the EIRR is held at PD site.	
11. Finalize Open Items List and Open Work List (Each open item will identify the required action for closure, actionee, due date, and whether closure is a constraint to shipment/turnover/installation/power up/etc.)	ERO/PD
12. Signing of Certification and Open Items List and Open Work List	
Scope of the items to be addressed are related to delivery purpose (i.e., flight processing, pre-flight interface testing, etc.)	

FIGURE 2-5 TYPICAL AGENDA FOR EIRR (Sheet 2 of 2)

2.3.5.1.2 The Open Work List

The open work list, referenced in Figure 2-8, shall be used by the EPIM and PD to identify and describe any work on the PD hardware/software that was intended to be complete before shipment to KSC. It shall include work or tests that previously had not been required to be performed at KSC but should not include those activities already provided for in the TDRS and previously submitted off-line procedure execution. The ERO's agreement with an acceptance of the open items and open work at EIRR also represents the acceptance of the equipment for shipment to KSC, unless any items were identified as constraints to shipment. The open work list is also combined with, and becomes a part of the certification.

The day that the PD arrives at KSC, there will be a pre-offline briefing conducted by KSC/LSSM with the PD at KSC. This is an informal meeting to make sure all is in place for the offline activities. When the PD off-line activities have been completed, a formal turnover review is conducted by KSC, involving PD, ERO and KSC in which the responsibility for the

EXPRESS PD Hardware/Software Certification and Acceptance	
Name:	Flight:

Certification:

This is to certify that:

1. All requirements defined in the payload-unique Interface Control Document, Payload Verification Plan, Command and Data Handling Data Set, Configuration Data Set, KSC Technical Requirements Data Set and KSC Support Requirements Data Set have been satisfied and the flight hardware/software and associated GSE are ready for integration/testing. Exceptions are contained in the attached open items list.

2. The flight hardware/software meets all safety requirements of NSTS 1700.7B, the ISS Addendum and KHB 1700.7B. The safety analyses documents all hazards associated with the flight hardware/software and all closeout actions have been accomplished as designated. All data reflect the as-built and delivered hardware/software configuration. Exceptions are contained in the attached open items list.

Payload Developer ____________________ Date __________

ERO Lead Systems Eng ____________________ Date __________

Acceptance:

This flight hardware/software and associated GSE are approved for shipment to KSC and, pending closure of the open items and open work as indicated on the attached lists, are acceptable for planned off-line activities and integration.

ERO Lead Systems Eng ____________________ Date __________

FIGURE 2-6 EXPRESS PD HARDWARE/SOFTWARE CERTIFICATION AND ACCEPTANCE

<table>
<tr><th colspan="6">EXPRESS PD Hardware/Software Open Items List</th></tr>
<tr><td colspan="3">Name:</td><td colspan="3">Flight:</td></tr>
<tr><td colspan="6">Signed by:

________________________ ________________
Payload Developer Date</td></tr>
<tr><td colspan="6">Accepted by:

________________________ ________________
ERO Lead Systems Eng Date</td></tr>
<tr><td rowspan="2">Open Item Number</td><td rowspan="2">Description</td><td rowspan="2">Constraints</td><td colspan="2">Closeout Responsible Signature and date</td></tr>
<tr><td>PD</td><td>ERO LSE</td></tr>
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</table>

FIGURE 2-7 EXPRESS PD HARDWARE/SOFTWARE OPEN ITEMS LIST

EXPRESS PD Hardware/Software Open Work List				
Name:			Flight:	
Signed by: ______________________ Payload Developer			______________ Date	
Accepted by: ______________________ ERO Lead Systems Eng			______________ Date	
______________________ KSC LSSM			______________ Date	
Open Item Number	Description	Constraints	PD Signature and Date	
			PD	Date

FIGURE 2-8 EXPRESS PD HARDWARE/SOFTWARE OPEN WORK LIST

flight hardware/software is officially handed over to KSC. At this time, the open work will be reviewed, accepted by KSC, and transferred to the KSC work authorization system for tracking and closeout.

2.3.6 Certification Maintenance

2.3.6.1 Series/Reflight Hardware

Verification for series/reflight hardware should be based on previously performed analyses, test, and inspections. The required safety assessments or reassessments for series/reflight hardware items are defined in NSTS 13830, Section 9.0. For verification of other interface requirement, previously developed and submitted verification data can and should be referenced or can be used as inputs to the ERO for integrated rack analyses. If the data has not previously been submitted to the ERO, even though it has been submitted to the ISS and/or PSRP, a copy of each of the verification data packages should be submitted to the ERO. This includes any series/reflight assessments. A statement which cross-references each individual series/reflight item to the previously submitted verification data packages must be included with the readiness statement for the series/reflight item.

2.3.6.2 EXPRESS Requirements Change Assessment Process

During the early phases of the assembly of the ISS, PD hardware interface and safety requirements will continue to evolve after the payload hardware ICDs and PVPs are baselined and may continue to do so even after the delivery of the payload hardware to the ISS. There are many project-level documents linked to the unique hardware ICDs and PVPs. Changes to these program-level documents force changes to each of the subordinate project-level documents.

In order to reconcile the design of the PD with the current set of requirements, the ISS has implemented a system by which each PD addresses the effects of the changes made to hardware interface and safety requirements. This will be performed either after the hardware verification program has been completed or the hardware has been delivered to the ISS and will not require periodic updates to the unique hardware ICDs and PVPs. This assessment will be part of the CoFR process also.

The EXPRESS requirements change assessment process is shown in Figure 2-9. The payload-unique ICD and PVP will be baselined consistent with the current versions of the ISS requirements documents at that time. The verification implementation process will be performed per the baselined unique PVP. The PD will continue to participate in the documentation update evaluation process (via Change Requests (CR), PIRNs, etc.) following the baseline of the unique ICD or PVP. The PD will identify impacts to hardware design or verification resulting from each requirement change. Impacts associated with each requirement change are presented to the ERO (and potentially the PTR or PCB) when the

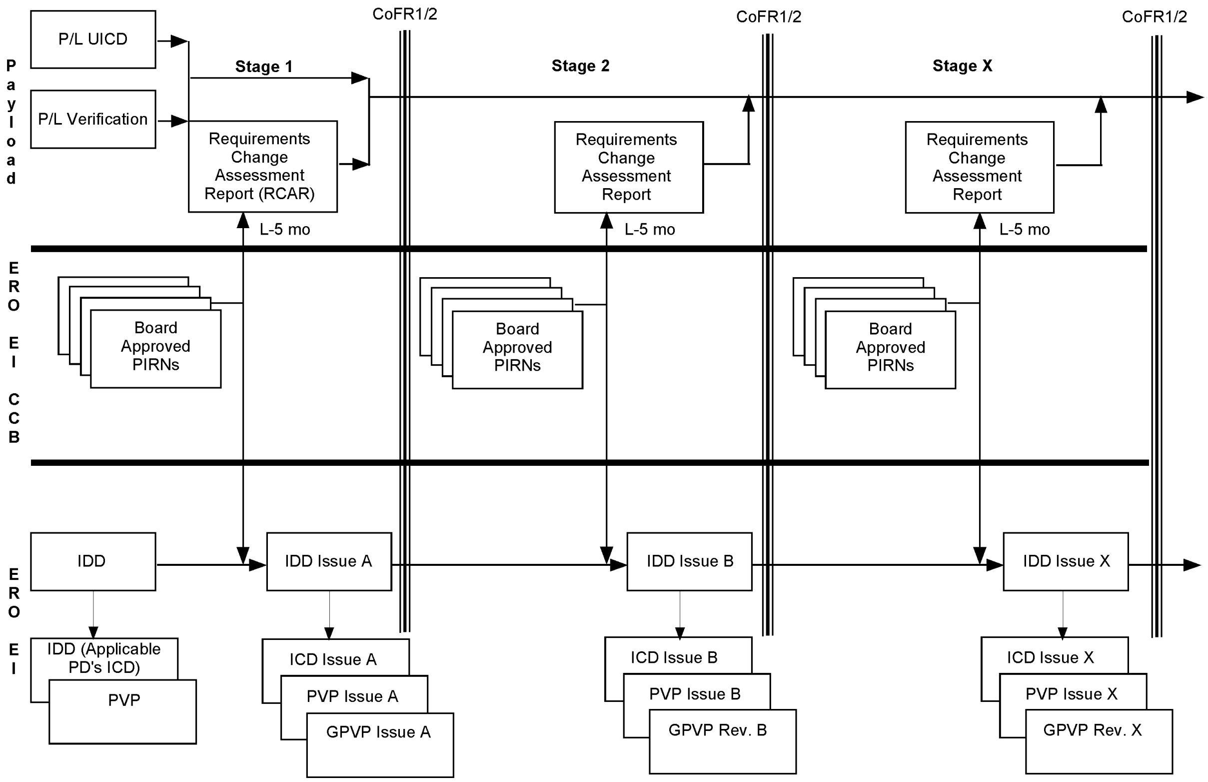

FIGURE 2-9 EXPRESS REQUIREMENTS CHANGE ASSESSMENT PROCESS

requirement is presented for baselining. The PCB authorizes specific PD exceptions to the new requirement or funding to address required hardware modifications or delta-verification activities. The PD documents the results of their assessments of the approved requirement changes in an EXPRESS Requirements Change Assessment Report (ERCAR) that will be submitted as a CoFR endorsement input. A sample ERCAR is presented in Appendix E.

The PD produced ERCAR for each stage/flight will consist of:

A. Identification of each requirement and its associated CR, PIRN, etc. for which:

    (1) There are no impacts.

    (2) An exception was approved.

    (3) Delta-verification activities were performed.

    (4) Which hardware modification was required.

B. Requirements change assessments.

C. Delta-verification data.

D. Statement of compliance to the defined Stage Requirements Set or to ISS and ERO approved exceptions.

Note: The definition of the Stage Requirements Set will be documented in the CoFR 1 Letter. This will require the CoFR 1 letter to be issued at L-22 weeks.

This process will allow for ERCARs to be submitted in lieu of major revisions to ICDs and PVPs if desired by the PD; however, the PD may choose to revise their ICD and PVP to keep them consistent with the latest ISS requirements documents. Any ICD/PVP revisions will be handled via the EPIM.

2.3.6.3 On-Orbit Verification/Reverification

Verification of payload interfaces and/or design features after installation in the EXPRESS Rack in orbit as well as after a specified time period are in the process of being defined. These verification/reverification requirements include:

A. Verification of certain safety-related interfaces prior to powering the payload item once in the ISS. This is especially important for those payloads that fly in the middeck and are transferred to the ISS/EXPRESS Rack. Items may include checking bonding/grounding connections, etc. Unless previously identified, the verification requirements identified herein fulfill this need.

B. Reverification of certain safety-related and mission success-related design features over time. Requirement and/or guidelines for these types of subjects have not been defined. These include the effects of time and life cycles on certain safety controls/inhibits. This may include O-rings/sealant degradation over time, calibration of sensors over time, etc. (reference MA2-98-135, dated 12/05/98)

C. NSTS 13830, Section 8.2.1, for other information regarding on-orbit reconfigured payloads.

2.4 PAYLOAD VERIFICATION TEMPLATE

Submittal dates for each piece of data required to close a verification requirement are identified on each VRDS. These dates are based on the needs of the Element Integrator (per SSP 57010) and the ISS Integrator (per SSP 57011). A comprehensive list of all deliverables is shown in SSP 57057. At this date, specific submittal data requirements and need dates different from the USL Integrator needed by the International Partners (IP) for their modules (i.e., Columbus Orbiting Facility (COF), Japanese Experiment Module (JEM), Centrifuge Accommodations Module (CAM) have not been identified.

APPENDIX A

VERIFICATION REQUIREMENTS LISTING

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TABLE A-I STRUCTURAL INTEGRITY VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
ST-ER-001	Structural Strength	3.4.3.6.2.1, 4.1.2, 4.2.1, 4.3.1, 4.3.2, 4.5.2, 4.6.1, 4.7.1	A-1
ST-ER-002	Crew-Applied Loads	4.5.1, 4.6.1	A-4
ST-ER-003	On-Orbit Depress/Repress	4.6.1, 4.8.1, 4.8.2, 4.8.3	A-5
ST-ER-004	Natural Frequency	4.1.1, 4.6.1	A-6
ST-ER-005	Acoustic Emission Limits	4.7.2.2, 4.7.2.2.1, 4.7.2.2.2, 4.7.2.2.3, 4.7.2.3, 4.7.2.4	A-7
ST-ER-006	Microgravity Environment	4.10.1, 4.10.2, 4.10.3, 4.11	A-9
ST-ER-007	Ground Transportation Loads	4.6.1, 4.9.1, 4.9.2	A-11
ST-ER-008	Fracture Control	4.6.2	A-13
ST-ER-009	Securing of Threaded Fasteners	3.4.3.6.4, 3.4.5, 3.4.5.1, 3.4.5.2(A-F), 4.6.1	A-15
ST-ER-010	Pressurized Systems	4.1.2, 4.2.1, 4.3.1, 4.3.2, 4.6.1, 5.3.1.5.11, 5.4.2, 5.5.3, 5.5.4	A-18
ST-ER-011	Weight and Center of Gravity	3.4.4.1C, 3.4.4.2B, 4.4.1, 4.4.2, 4.4.3	A-20
ST-ER-012	Portable Fire Extinguisher (PFE) Discharge Rate	4.8.4	A-22
ST-ER-013	Late/Early Access Requirement	3.5.2, 3.5.2.1(A-C), 3.5.2.2(A-B)	A-23
ST-MD-001	Orbiter/Middeck Attach Point Provisions	3.4.3.6.1	A-25
ST-MD-002	Middeck (MD) Natural Frequency	4.1.1	A-26
ST-MD-003	MD Crew-Applied Loads	4.5.1	A-27
ST-MD-004	MD Acoustic Levels	4.7.2.2, 4.7.2.2.1, 4.7.2.2.2, 4.7.2.2.3	A-28

TABLE A-II MECHANICAL VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
ME-ER-001	EXPRESS Mounting Plates	3.4.1.1, 3.4.1.2	A-29
ME-ER-002	Standard Modular Locker	3.4.2.2, 3.4.2.3(A-B), 3.4.2, 3.4.2.4, 3.4.2.5	A-30
ME-ER-003	PD-Supplied Locker Requirements	3.4.2.6A	A-32
ME-ER-004	Mounting Panels	3.4.3, 3.4.3.1, 3.4.3.2, 3.4.3.3, 3.4.3.4	A-33
ME-ER-005	On-Orbit Separation Interface Requirements	3.3.1.2, 3.4.3.5.1(A-C)	A-35
ME-ER-006	EXPRESS Rack Backplate	3.4.3.6.2, 3.4.3.6.2.1, 3.4.3.6.2.2	A-36
ME-ER-007	Fastener Requirements	3.4.3.6.3	A-37
ME-ER-008	International Subrack Interface Standard (ISIS) Drawer Requirements	3.4.4.1(A-E), 3.4.4.2(A-G)	A-38
ME-ER-009	Payload Static Envelopes	3.6.1(A-C)	A-41
ME-MD-001	Orbiter Inlet/Outlet Locations	3.4.3.4.1, 3.4.3.4.1.1, 3.4.3.4.1.2	A-42
ME-MD-002	Closeout Cover Access	3.4.3.5.2	A-44
ME-MD-003	Orbiter Overhead Window Interface Requirements	3.9	A-45

TABLE A-III ELECTRICAL VERIFICATION REQUIREMENTS LISTING (Sheet 1 of 2)

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
EL-ER-001	Voltage Levels	6.2.1.1	A-46
EL-ER-002	Deleted	Deleted	Deleted
EL-ER-003	Reverse Current/Energy	6.2.1.3, 6.2.1.4	A-47
EL-ER-004	Soft Start/Stop	6.2.1.5	A-48
EL-ER-005	Overload Protection Device	6.2.2.1, 6.2.2.1.1, 6.2.2.1.2, 6.2.2.1.3, 6.2.2.1.4, 14.1.3	A-49
EL-ER-006	Current Limiting	6.2.3(A-D), 14.1.3	A-51
EL-ER-007	Ripple and Transient Spikes (Repetitive) Limits - ISS	6.4, 6.4.1, 6.4.2	A-53
EL-ER-008	Batteries	6.5.2.1	A-55
EL-ER-009	Safety-Critical Circuits	6.5.2.2(A-C)	A-56
EL-ER-010	Electrical Hazards	6.5.2.3(B-E), 6.5.3, 6.5.3.1, 6.5.4, 6.5.5	A-58
EL-ER-011	Electrical Connectors	6.6.1, 6.6.5, 6.6.6	A-61
EL-ER-012	Electrical Connectors Mating/Demating (Unpowered)	6.6.2	A-63
EL-ER-013	Electrical Connectors Mating/Demating (Powered)	6.6.3A, 6.6.3.8, 6.6B(1-4), 6.6.3, 12.7.3	A-64
EL-ER-014	Electrical Connector Mismating Prevention	6.6.4, 6.6.4(A-D), 12.7.1	A-66
EL-ER-015	Conducted and Radiated Emissions	7.3.1, 7.3.1.1, 7.3.1.3, 7.3.1.3.2, 7.3.1.3.4, 7.3.1.3.6, 7.3.1.5.3, 7.3.1.5.4	A-69
EL-ER-016	Conducted and Radiated Susceptibility	7.3.1, 7.3.1.1, 7.3.1.4.2, 7.3.1.4.4, 7.3.1.4.6, 7.3.1.6.3(A-B), 7.3.1.7.2	A-72
EL-ER-017	ESD Compatibility/Labeling	7.3.2.1, 7.3.2.2, Appendix E (3.5.9I)	A-75
EL-ER-018	Corona	7.3.2.3	A-76
EL-ER-019	Alternating Current (ac)/Direct Current (dc) Magnetic Fields for EXPRESS Rack Payloads in the ISS	7.4.3.1, 7.4.3.2	A-77
EL-ER-020	Electrical Bonding	7.5.1, 7.5.1(A-D)	A-79

TABLE A-III ELECTRICAL VERIFICATION REQUIREMENTS LISTING (Sheet 2 of 2)

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
EL-ER-021	Electrical Bonding of Payload Hardware	7.5.1.1	A-81
EL-ER-022	Electrical Bonding of Payload Structures	7.5.1.2.1.1, 7.5.1.2.1.2, 7.5.1.2.1.3	A-83
EL-ER-023	Power Circuit Isolation and Grounding	7.6.1, 7.6.3	A-85
EL-ER-024	Signal Isolation and Grounding Requirements	7.7.1, 7.7.2, 7.7.3, 7.7.4, 7.7.5, 7.7.6	A-87
EL-ER-025	Deleted	Deleted	Deleted
EL-ER-026	Pin Functions MDLs/MDL Replacement	8.1.1.1, 8.1.1.2, 8.1.1.1.1	A-89
EL-ER-027	Approved Connectors for EXPRESS Rack Payload Use	8.1.2	A-90
EL-ER-028	Deleted	Deleted	Deleted
EL-ER-029	GSE Isolation and Grounding	7.6.4	A-91
EL-MD-001	In-Flight dc Power Bus Ripple/Transient Spikes (Repetitive) at the Interface - Shuttle	6.3.1(A, B), 6.3.2, 7.2.1	A-92
EL-MD-002	Ground dc Power - Shuttle/Middeck	6.3.3	A-94
EL-MD-003	ac Power Characteristics - Shuttle/Middeck	6.3.4	A-95
EL-MD-004	Radiated Interference - Shuttle/Middeck	7.2.1.1, 7.2.2, 7.2.2B, 7.3	A-96
EL-MD-005	Payload-Produced Conducted Noise - Shuttle	7.3, 7.4.1(A-C)	A-98
EL-MD-006	Payload-Produced Radiated Fields - Shuttle	7.3, 7.4.2(A-D)	A-100

TABLE A-IV COMMAND AND DATA HANDLING VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
CD-ER-001	RS-422 Signal Interface	9.1.1, 9.1.2, 9.1.3, 9.1.4, 11.2.3.5, 11.2.3.5.1, 11.2.3.5.2, 11.2.3.5.3, 11.2.3.5.4, 11.2.3.5.5, 11.2.3.5.5.1, 11.2.3.5.5.2, 11.2.3.7	A-102
CD-ER-002	RS-422, Ethernet, Analog, Discrete, Video, and Point-to-Point Connector/Pin Interface	9.1.5.1, 9.1.5.2, 9.2.6.1, 9.2.6.2, 9.3.3.1, 9.3.3.2, 9.4.3.1, 9.4.3.2, 9.5, 9.6, 9.7.3	A-104
CD-ER-003	Ethernet Signal Interface	9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.2.5, 11.2.3.5, 11.2.3.5.1, 11.2.3.5.2, 11.2.3.5.3, 11.2.3.5.4, 11.2.3.5.5, 11.2.3.5.5.1, 11.2.3.5.5.2, 11.2.3.7	A-105
CD-ER-004	Analog Signal Characteristics	9.3.1, 9.3.2	A-107
CD-ER-005	Discrete I/O Signal Characteristics	9.4.1.1, 9.4.1.2, 9.4.1.3, 9.4.1.4, 9.4.1.5, 9.4.1.6	A-108
CD-ER-006	Discrete Driver/Receiver Characteristics	9.4.2	A-110
CD-ER-007	Video Signal Interface	9.7, 9.7.1.1, 9.7.1.2, 9.7.1.3, 9.7.1.4	A-111

TABLE A-V SOFTWARE AND COMPUTERS VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
SW-ER-001	Orbiter PGSC DC Power RS-232/RS-422 Connector/Pinout	11.1.1, 11.1.1.2.1, 11.1.1.2.2, 11.1.1.2.3	A-113
SW-ER-002	Orbiter Payload and General Support Computer (PGSC) Software Interfaces	11.1.1.3	A-115
SW-ER-003	EXPRESS Rack Rack Interface Controller (RIC) RS-422 Interface	11.2.2, 11.2.3.1, 11.2.3.3, 11.2.3.4, 11.2.3.5, 11.2.3.5.5, 11.2.3.6, 11.2.3.7	A-116
SW-ER-004	EXPRESS Rack Payload Ethernet Hub Bridge (PEHB) Ethernet Interface	11.2.1, 11.2.3.1, 11.2.3.3, 11.2.3.4, 11.2.3.5, 11.2.3.5.5, 11.2.3.6, 11.2.3.7, 11.2.4, 11.2.4.4A, 11.2.4.4C	A-118
SW-ER-005	Portable Computer System (PCS) Interfaces	11.1.3	A-121
SW-ER-006	Software Safety Requirements for Payloads	11.3	A-122
SW-ER-007	Payload Display and File Transfer Requirements for Payload Application Software	11.2.3.5.5, 11.2.4.2, 11.2.4.3, 11.2.4.4C, 11.2.4.4A, 11.2.4.5	A-123
SW-ER-008	Payload Command Ground Interface	11.2.3.7	A-125

TABLE A-VI THERMAL CONTROL VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
TH-ER-001	Touch Temperature	5.1.1A, 5.1.1B, 5.1.1C	A-126
TH-ER-002	Condensation Prevention (All Equipment Surfaces)	5.1.2, 5.1.2.1	A-128
TH-ER-003	Loss of Cooling	5.1.3	A-130
TH-ER-004	Pressure Relief/Vent Valve Sizing	5.1.4	A-132
TH-ER-005	On-Orbit Environmental Conditions	5.2	A-134
TH-ER-006	Passive Cooling/Heating of Cabin	5.3.1.1.2, 5.3.1.1.3, 5.3.1.3.7	A-135
TH-ER-007	Middeck Cabin Cooling Interfaces	5.3.1.2, 5.3.1.4.3	A-137
TH-ER-008	Particulate(s) and Filters	5.3.1.2.1, 5.3.1.3.5	A-139
TH-ER-009	Forced Air Flow Cooling	5.3.1.3.2, 5.3.1.3.1.3, 5.3.1.3.3.1, 5.3.1.3.3.2, 5.3.1.4.4, 5.3.1.3.4	A-140
TH-ER-010	Physical Interface	5.3.1.5.1, 5.3.1.5.2(A-D), 5.3.1.5.3, 5.3.1.5.4, 5.3.1.5.5, 5.3.1.5.6, 5.3.1.5.7, 5.3.1.5.8, 5.3.1.5.9, 5.3.1.5.10, 5.3.1.5.11	A-142
TH-ER-011	GN_2 Interfaces	5.5.1, 5.5.2, 5.5.3, 5.5.4, 5.5.5, 5.5.6, 5.5.7	A-146
TH-ER-012	Sealing Surface	5.3.1.3.1.4, 5.3.1.3.1.5	A-148
TH-ER-013	Payload Front Surface Temperature	5.3.1.1.1	A-149
TH-ER-014	Middeck Ducted Air Cooling Capability	5.3.1.4, 5.3.1.4.6, 5.3.1.4.7, 5.3.1.4.8	A-150
TH-ER-015	Attached Pressurized Module (APM)/JEM/CAM Unique Thermal Control Interface Requirements	5.3.2	A-152

TABLE A-VII VACUUM EXHAUST VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
VC-ER-001	Vacuum Exhaust Physical Interface	5.4.1, 5.4.2, 5.4.3, 5.4.4, 5.4.5, 5.4.6, 5.4.7, 5.4.7.1(A-D), 5.4.7.2, 5.4.7.3A, 5.4.7.3B, 5.4.8	A-153

TABLE A-VIII ENVIRONMENTAL VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
EN-ER-001	Deleted	Deleted	Deleted
EN-ER-002	Laser Requirements	10.3.1, 10.3.2, 10.3.3, 10.3.4, 10.3.5, 10.3.6	A-158
EN-ER-003	Radiation Requirements	10.4.1, 10.4.2, 10.4.3	A-160
EN-ER-004	Atmosphere Requirements	10.5.1, 10.5.2	A-162

TABLE A-IX FIRE DETECTION/SUPPRESSION VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
FP-ER-001	Fire Protection Interface Requirements	14.1	A-163
FP-ER-002	Oxygen	14.1.2(A-C)	A-164
FP-ER-003	Payload Use of Battery Backup Power	14.1.4	A-166
FP-ER-004	Payload Data Monitoring	14.2, 14.2A, 14.2B, 14.2C(1-3)	A-168
FP-ER-005	PFE Access Port	14.3C, 14.3D, 14.3E, 14.3.1, 14.3.2, 14.3.3, 14.3.4, 14.3.5	A-171
FP-ER-006	Fire Suppressant Distribution	14.4	A-175

TABLE A-X MATERIALS AND PARTS VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
MP-ER-001	Materials and Parts	5.3.1.5.2A, 5.3.1.5.2B, 5.3.1.5.2C, 10.1(A-B), 13.1, 13.1.1, 13.1.2, 13.1.3, 13.1.4, 13.2, 13.3, 13.4, 14.1.1	A-177

TABLE A-XI HUMAN FACTORS VERIFICATION REQUIREMENTS LISTING
(Sheet 1 of 2)

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
HF-ER-001	Handles, Restraints, Tether Points, and Captive Parts	12.1.1, 12.1.2, 12.1.3, 12.1.4, 12.1.5(A-C), 12.1.6, 12.1.7, 12.1.8	A-182
HF-ER-002	Strength and Force Requirements	12.2A(1), 12.2A(2), 12.2A(3), 12.2B, 12.4.5	A-185
HF-ER-003	Full Size Range, Volume and Accessibility Accommodation	12.3.1, 12.3.2(A-B), 12.3.3	A-187
HF-ER-004	Equipment Mounting	12.4.1	A-189
HF-ER-005	Drawers and Hinged Panels	12.4.2	A-190
HF-ER-006	Alignment, Align Marks, Guide Pins	12.4.3, 12.7.12, 12.5.3A, 12.5.3B	A-191
HF-ER-007	Slide-Out Stops	12.4.4	A-193
HF-ER-008	Access, Closures, Covers, and Tools	12.4.6, 12.4.6.1(A-C), 12.4.6.2, 12.9.1, 12.12.12	A-194
HF-ER-009	Deleted	Deleted	Deleted
HF-ER-010	Deleted	Deleted	Deleted
HF-ER-011	Labeling Design Requirements	12.5	A-196
HF-ER-012	Deleted	Deleted	Deleted
HF-ER-013	Deleted	Deleted	Deleted
HF-ER-014	Color	12.5.1	A-197
HF-ER-015	Fluid Connector Pressure/Flow Indicator	12.5.2, 12.7.10, 12.7.11	A-198
HF-ER-016	Deleted	Deleted	Deleted
HF-ER-017	Controls Spacing Design	12.6.1, 12.6.2.2, 12.6.2.4	A-200
HF-ER-018	Accidental Actuation - Protection	12.6.2.1(B-D), 12.6.2.5, 12.6.2.6, 12.6.2.7, 12.6.2.8	A-202
HF-ER-019	Valve Controls	12.6.3A, 12.6.3B, 12.6.3C, 12.6.3D, 12.6.3E	A-205
HF-ER-020	Toggle Switches	12.6.4	A-207
HF-ER-021	Audio Devices (Displays)	12.6.6A, 12.6.6B, 12.6.6C	A-208
HF-ER-022	Electrical Connectors Design (One-Hand Operation, Ease of Disconnect, Self-Locking)	12.7.5, 12.7.6A(1), 12.7.6A(2), 12.7.6B, 12.7.7A, 12.7.7B, 12.7.8	A-210

TABLE A-XI HUMAN FACTORS VERIFICATION REQUIREMENTS LISTING
(Sheet 2 of 2)

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
HF-ER-023	Electrical Connectors Design - Protection, Shape, and Arc Containment	12.5.4, 12.7.2, 12.7.3, 12.7.9	A-212
HF-ER-024	Arrangement and Orientation for Connectors	12.7.4A, 12.7.4B, 12.7.13	A-214
HF-ER-025	Hose/Cable Restraints	12.8A, 12.8B, 12.8C	A-216
HF-ER-026	Built-In Control	12.9.2A, 12.9.2B	A-218
HF-ER-027	One-Handed Cleaning Operation	12.9.3	A-219
HF-ER-028	Waste Management	12.10	A-220
HF-ER-029	Mechanical Energy Devices	12.11	A-221
HF-ER-030	Other Non-Threaded Fasteners	12.12.1, 12.12.5A, 12.12.5B, 12.12.8	A-222
HF-ER-031	Mounting Bolt and Fasteners	3.4.3.5, 3.4.3.5.1B, 3.4.3.5.1C, 12.12.2, 12.12.3, 12.12.4, 12.12.6, 12.12.9A, 12.12.9B, 12.12.9C, 12.12.10, 12.12.11	A-224
HF-ER-032	Latches	12.6.5A, 12.6.5B, 12.12.7A, 12.12.7B, 12.12.7C	A-228
HF-ER-033	Payload In-Flight Maintenance	12.13	A-230
HF-ER-034	Protrusions (Permanent/Temporary) and Pathways	3.6.2(A-B), 3.6.2.1, 3.6.2.2(A-B), 3.6.2.3(A-B), 3.6.2.4, 3.6.2.5, 3.8	A-231
HF-ER-035	Sharp Edges/Corners Requirements	3.6.3, 3.6.3.1, 3.6.3.2, 3.6.3.3, 3.6.3.4, 3.6.3.5, 3.6.3.6, 3.6.3.7, 3.6.3.8	A-235
HF-ER-036	Restraints and Mobility Aids Interface Compatibility	3.7.2	A-238
HF-ER-037	PD Stowage Tray Requirements	3.4.2.3A, 3.4.2.3B, 3.4.2.3C, 3.4.4.1D, 3.4.4.1E	A-239
HF-ER-038	Deleted	Deleted	Deleted
HF-ER-039	Identification Labeling	12.5	A-241

TABLE A-XII SAFETY SPECIFIC VERIFICATION REQUIREMENTS LISTING

VRDS NO.	VERIFICATION REQUIREMENT TITLE	IDD PARAGRAPH NUMBERS	VRDS PAGE NO.
SA-ER-001	Payload Safety Requirements	1.2	A-242

APPENDIX B

IDD CROSS-REFERENCE MATRIX

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TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 1 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	1.2	Scope	SA-ER-001
NAR	3.1	Geometric Relationships	
NAR	3.1.1	Crew Module (CM) Coordinate System	
NAR	3.1.2	International Standard Payload Rack (ISPR) Coordinate System	
NAR	3.1.3	Payload Coordinate System	
NAR	3.2	Dimensions and Tolerances	
NAR	3.3	Mechanical Interfaces	
NAR	3.3.1	Middeck Locations	
NAR	3.3.1.1	Avionics Bay Locations and Middeck Payload Provisions	
	3.3.1.2	Middeck Payload Provisions	ME-ER-005
NAR	3.3.2	ISS Locations	
NAR	3.3.2A	ISS Locations	
NAR	3.3.2B	ISS Locations	
NAR	3.3.2C	ISS Locations	
NAR	3.4	Mechanical Payload Provisions	
NAR	3.4.1	EXPRESS Mounting Plates	
	3.4.1.1	8/2 EXPRESS Rack Mounting Plates	ME-ER-001
	3.4.1.2	EXPRESS Transportation Rack Mounting Plates	ME-ER-001
	3.4.2	Standard Modular Locker	ME-ER-002
NAR	3.4.2.1	Standard Stowage Trays	
	3.4.2.2	Modified Locker Access Door	ME-ER-002
NAR	3.4.2.3	Payload Zero “g” Requirements	
	3.4.2.3A	Payload Zero “g” Requirements	HF-ER-037, ME-ER-002
	3.4.2.3B	Payload Zero “g” Requirements	HF-ER-037, ME-ER-002
	3.4.2.3C	Payload Zero “g” Requirements	HF-ER-037
	3.4.2.4	Isolation Material Properties	ME-ER-002
	3.4.2.5	ISS-Supplied Lockers	ME-ER-002
NAR	3.4.2.6	PD-Supplied Locker Requirements	
	3.4.2.6A	PD-Supplied Locker Requirements	ME-ER-003
NAR	3.4.2.6B	PD-Supplied Locker Requirements	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 2 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	3.4.2.6B(1)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(2)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(3)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(4)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(5)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(6)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(7)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(8)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(9)	PD-Supplied Locker Requirements	
NAR	3.4.2.6B(10)	PD-Supplied Locker Requirements	
	3.4.3	Mounting Panels	ME-ER-004
	3.4.3.1	Single Adapter Plate	ME-ER-004
	3.4.3.2	Double Adapter Plate	ME-ER-004
	3.4.3.3	Payload Mounting Panel	ME-ER-004
	3.4.3.4	Vented Payload Mounting Panel	ME-ER-004
	3.4.3.4.1	Orbiter Inlet/Outlet Locations for Ducted Air-Cooled Payloads	ME-MD-001
	3.4.3.4.1.1	Orbiter Inlet/Outlet Locations for Single Payload Accommodations	ME-MD-001
	3.4.3.4.1.2	Orbiter Inlet/Outlet Locations for Double Payload Accommodations	ME-MD-001
	3.4.3.5	Mounting Access	HF-ER-031
NAR	3.4.3.5.1	On-Orbit Separation Interface Requirements	
	3.4.3.5.1A	On-Orbit Separation Interface Requirements	ME-ER-005
	3.4.3.5.1B	On-Orbit Separation Interface Requirements	HF-ER-031, ME-ER-005
	3.4.3.5.1C	On-Orbit Separation Interface Requirements	HF-ER-031, ME-ER-005
	3.4.3.5.2	Closeout Cover Access	ME-MD-002
NAR	3.4.3.6	Payload Attachment Point Provisions	
	3.4.3.6.1	Orbiter/Middeck	ST-MD-001
	3.4.3.6.2	EXPRESS Rack Backplate	ME-ER-006
	3.4.3.6.2.1	Interface Attachment Receptacle Capabilities	ME-ER-006, ST-ER-001
	3.4.3.6.2.2	Maximum Dimensions Envelope	ME-ER-006

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 3 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	3.4.3.6.3	Captive Fasteners	ME-ER-007
	3.4.3.6.4	On-Orbit Removal of Fasteners	ST-ER-009
NAR	3.4.4	ISIS Drawer Payload Provisions	
NAR	3.4.4.1	Stowage ISIS Drawers	
	3.4.4.1A	Stowage ISIS Drawers	ME-ER-008
	3.4.4.1B	Stowage ISIS Drawers	ME-ER-008
	3.4.4.1C	Stowage ISIS Drawers	ME-ER-008, ST-ER-011
	3.4.4.1D	Stowage ISIS Drawers	ME-ER-008, HF-ER-037
	3.4.4.1E	Stowage ISIS Drawers	ME-ER-008, HF-ER-037
NAR	3.4.4.2	Powered ISIS Drawers	
	3.4.4.2A	Powered ISIS Drawers	ME-ER-008
	3.4.4.2B	Powered ISIS Drawers	ME-ER-008, ST-ER-011
	3.4.4.2C	Powered ISIS Drawers	ME-ER-008
	3.4.4.2D	Powered ISIS Drawers	ME-ER-008
	3.4.4.2E	Powered ISIS Drawers	ME-ER-008
	3.4.4.2F	Powered ISIS Drawers	ME-ER-008
	3.4.4.2G	Powered ISIS Drawers	ME-ER-008
NAR	3.4.4.3	ISIS Drawer Replacement	
	3.4.5	Securing of Threaded Fasteners	ST-ER-009
	3.4.5.1	Fracture-Critical Threaded Fasteners	ST-ER-009
NAR	3.4.5.2	Redundant Threaded Fasteners Locking Requirements	
	3.4.5.2A	Redundant Threaded Fasteners Locking Requirements	ST-ER-009
	3.4.5.2B	Redundant Threaded Fasteners Locking Requirements	ST-ER-009
	3.4.5.2C	Redundant Threaded Fasteners Locking Requirements	ST-ER-009
	3.4.5.2D	Redundant Threaded Fasteners Locking Requirements	ST-ER-009
	3.4.5.2E	Redundant Threaded Fasteners Locking Requirements	ST-ER-009

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 4 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE	VRDS NO.
	3.4.5.2F	Redundant Threaded Fasteners Locking Requirements	ST-ER-009
NAR	3.5	Ground Support Equipment (GSE)	
NAR	3.5.1	Ground Handling	
	3.5.2	Multipurpose Logistics Module (MPLM) Late/Early Access Requirement	ST-ER-013
NAR	3.5.2.1	MPLM Late Access Envelope (KSC)	
	3.5.2.1A	MPLM Late Access Envelope (KSC)	ST-ER-013
	3.5.2.1B	MPLM Late Access Envelope (KSC)	ST-ER-013
	3.5.2.1C	MPLM Late Access Envelope (KSC)	ST-ER-013
NAR	3.5.2.2	MPLM Early Access Envelopes (KSC and Dryden Flight Research Center (DFRC))	
	3.5.2.2A	MPLM Early Access Envelopes (KSC and DFRC)	ST-ER-013
	3.5.2.2B	MPLM Early Access Envelopes (KSC and DFRC)	ST-ER-013
NAR	3.6	Envelope Requirements	
NAR	3.6.1	Payload Static Envelopes	
	3.6.1A	Payload Static Envelopes	ME-ER-009
	3.6.1B	Payload Static Envelopes	ME-ER-009
	3.6.1C	Payload Static Envelopes	ME-ER-009
NAR	3.6.2	On-Orbit Payload Protrusions	
	3.6.2A	On-Orbit Payload Protrusions	HF-ER-034
	3.6.2B	On-Orbit Payload Protrusions	HF-ER-034
	3.6.2.1	Front Face Protrusions (Permanent)	HF-ER-034
NAR	3.6.2.2	On-Orbit Semi-Permanent Protrusions	
	3.6.2.2A	On-Orbit Semi-Permanent Protrusions	HF-ER-034
	3.6.2.2B	On-Orbit Semi-Permanent Protrusions	HF-ER-034
NAR	3.6.2.3	On-Orbit Temporary Protrusions	
	3.6.2.3A	On-Orbit Temporary Protrusions	HF-ER-034
	3.6.2.3B	On-Orbit Temporary Protrusions	HF-ER-034
	3.6.2.4	On-Orbit Momentary Protrusions	HF-ER-034
	3.6.2.5	On-Orbit Protrusions for Keep-Alive Payloads	HF-ER-034
	3.6.3	Sharp Edges and Corners	HF-ER-035
	3.6.3.1	Protective Covers/Shields	HF-ER-035
	3.6.3.2	Holes	HF-ER-035
	3.6.3.3	Screws/Bolts Ends	HF-ER-035
	3.6.3.4	Burrs	HF-ER-035

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 5 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	3.6.3.5	Latches	HF-ER-035
	3.6.3.6	Levers, Cranks, Hooks, and Controls	HF-ER-035
	3.6.3.7	Safety/Lockwire	HF-ER-035
	3.6.3.8	Securing Pins	HF-ER-035
NAR	3.7	Mechanical Interfaces for Crew Restraints/Mobility Aids	
NAR	3.7.1	Hardware Definition	
	3.7.2	Interface Compatibility	HF-ER-036
	3.8	Intravehicular Activity (IVA) Transfer Pathway	HF-ER-034
	3.9	Orbiter Overhead Window Interface Requirements	ME-MD-003
NAR	4.1	Operational Loads	
	4.1.1	Component Frequency	ST-ER-004, ST-MD-002
	4.1.2	Payload Low Frequency Launch and Landing Loads	ST-ER-001, ST-ER-010
NAR	4.2	Emergency Landing Loads Factors	
	4.2.1	Middeck	ST-ER-001, ST-ER-010
NAR	4.2.2	MPLM	
NAR	4.3	Random Vibration	
	4.3.1	Random Vibration - MPLM	ST-ER-001, ST-ER-010
	4.3.2	Random Vibration - Middeck	ST-ER-001, ST-ER-010
NAR	4.4	EXPRESS Rack MDL Location Interface Loads	
	4.4.1	Single MDL Location Interface Loads	ST-ER-011
	4.4.2	Double MDL Location Interface Loads	ST-ER-011
	4.4.3	Quad MDL Location Interface Loads	ST-ER-011
NAR	4.5	On-Orbit Loads	
	4.5.1	Crew-Induced Loading	ST-ER-002, ST-MD-003
	4.5.2	On-Orbit Low Frequency Loads	ST-ER-001
NAR	4.6	EXPRESS Rack Payload Structural Design	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 6 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	4.6.1	Structural Design	ST-ER-001, ST-ER-002, ST-ER-003, ST-ER-004, ST-ER-007, ST-ER-009, ST-ER-010
	4.6.2	Fracture Control	ST-ER-008
NAR	4.7	Acoustics	
	4.7.1	Lift-Off and Ascent Acoustics	ST-ER-001
NAR	4.7.2	Payload-Generated Acoustic Noise	
NAR	4.7.2.1	Acoustic Noise Definitions	
NAR	4.7.2.1.1	Significant Noise Source	
NAR	4.7.2.1.2	Continuous Noise Source	
NAR	4.7.2.1.3	Intermittent Noise Source	
NAR	4.7.2.1.4	Acoustic Reference	
	4.7.2.2	Acoustic Noise Limits	ST-ER-005, ST-MD-004
	4.7.2.2.1	Continuous Noise Limits	ST-ER-005, ST-MD-004
	4.7.2.2.2	Intermittent Noise Limits	ST-ER-005, ST-MD-004
	4.7.2.2.3	Continuous Noise Sources with Intermittent Noise Features	ST-ER-005, ST-MD-004
NAR	4.7.2.2.3A	Continuous Noise Sources with Intermittent Noise Features	
NAR	4.7.2.2.3B	Continuous Noise Sources with Intermittent Noise Features	
NAR	4.7.2.2.3C	Continuous Noise Sources with Intermittent Noise Features	
	4.7.2.3	Sound Power Readings on Payloads	ST-ER-005
	4.7.2.4	Acoustic Test Plan for Payloads	ST-ER-005
NAR	4.8	Depressurization/Repressurization Requirements	
	4.8.1	USL, APM, CAM, and JEM Maximum Depressurization/ Repressurization Rates	ST-ER-003
	4.8.2	MPLM Maximum Depressurization/Repressurization Rate	ST-ER-003

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 7 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	4.8.3	Middeck Maximum Depressurization/Repressurization Rates	ST-ER-003
	4.8.4	PFE Discharge Rate	ST-ER-012
NAR	4.9	Ground Handling Environments	
	4.9.1	Ground Handling Load Factors	ST-ER-007
	4.9.2	Ground Handling Shock Criteria	ST-ER-007
NAR	4.10	Microgravity Disturbances	
TBD - ISS	4.10.1	Payload-Induced Quasi-Steady Disturbance	ST-ER-001, ST-ER-006
TBD - ISS	4.10.2	Payload-Induced Transient Disturbance	ST-ER-001, ST-ER-006
TBD - ISS	4.10.3	Payload-Induced Vibratory Disturbance	ST-ER-001, ST-ER-006
	4.11	Constraints for Active Isolation System (ARIS) EXPRESS Rack Activity	ST-ER-006
NAR	5.1	General Requirements	
NAR	5.1.1	External Surface (Touch) Temperature	
	5.1.1A	Intentional/Incidental Contact - High Temperature	TH-ER-001
	5.1.1B	Intentional/Incidental Contact - Low Temperature	TH-ER-001
	5.1.1C	External Surface (Touch) Temperature	TH-ER-001
	5.1.2	Condensation Prevention	TH-ER-002
	5.1.2.1	Condensation Prevention (Refrigerators/Freezers)	TH-ER-002
	5.1.3	Loss of Cooling	TH-ER-003
	5.1.4	Pressure Relief/Vent Valve Sizing	TH-ER-004
	5.2	ISS Laboratory (Cabin) Environmental Conditions	TH-ER-005
NAR	5.3	Payload Element Cooling	
NAR	5.3.1	Payload Heat Dissipation	
NAR	5.3.1.1	Passive Cooling	
	5.3.1.1.1	Payload Front Surface Temperature	TH-ER-013
	5.3.1.1.2	Cabin Air Heat Leak	TH-ER-006
	5.3.1.1.3	Convective Heat Transfer Coefficient	TH-ER-006
	5.3.1.2	Active Cabin Air Cooling/Heating Interface	TH-ER-007
	5.3.1.2.1	Particulate(s) and Filters/Debris Traps	TH-ER-008
NAR	5.3.1.3	Avionics Air Cooling	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 8 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	REQUIREMENT TITLE	VRDS NO.
NAR	5.3.1.3.1	Physical Interface	
NAR	5.3.1.3.1.1	MDLs	
NAR	5.3.1.3.1.2	ISIS Drawers	
	5.3.1.3.1.3	Fans	TH-ER-009
	5.3.1.3.1.4	Sealing Surfaces	TH-ER-012
	5.3.1.3.1.5	Maximum Air Leakage Across Payload Mounting Interface	TH-ER-012
	5.3.1.3.2	Air Supply Temperature	TH-ER-009
NAR	5.3.1.3.3	Air Flow Rate	
	5.3.1.3.3.1	MDLs	TH-ER-009
TBD - ISS	5.3.1.3.3.2	ISIS Drawers	TH-ER-009
	5.3.1.3.4	Air Return Temperature	TH-ER-009
	5.3.1.3.5	Payload Inlet Debris Traps	TH-ER-008
NAR	5.3.1.3.6	Maximum Allowable Heat Dissipation	
	5.3.1.3.7	Payload Limitations on Heat Conducted to Structure	TH-ER-006
	5.3.1.4	Middeck Ducted Air Cooling	TH-ER-014
NAR	5.3.1.4.1	Bay 1 Ducted Air Cooling Capability	
NAR	5.3.1.4.1.1	Bay 1 Standard Air Flow Capability	
NAR	5.3.1.4.1.2	Bay 2 Ducted Air Cooling Capability	
NAR	5.3.1.4.1.2.1	Bay 2 Standard Air Cooling Capability	
NAR	5.3.1.4.2	Bay 3A Ducted Air Cooling Capability	
NAR	5.3.1.4.2.1	Bay 3A Standard Air Flow Capability	
	5.3.1.4.3	Payload Limitations on Heat Conducted	TH-ER-007
	5.3.1.4.4	Payload Outlet Air Pressure Requirement	TH-ER-009
NAR	5.3.1.4.5	Ducted Payload Air Cooling Interface	
NAR	5.3.1.4.5.1	Single Size MDL Payload Air Cooling Interface	
NAR	5.3.1.4.5.2	Double Size MDL Payload Air Cooling Interface	
	5.3.1.4.6	Cabin and Avionics Bay Air Mixing Limitations	TH-ER-014
	5.3.1.4.7	Ducted Payload Limitations on Heat Convected or Radiated to Cabin Air	TH-ER-014
	5.3.1.4.8	Maximum Air Leakage Across Payload Mounting Interface Requirement	TH-ER-014
NAR	5.3.1.5	Water Loop Interface Requirements	
	5.3.1.5.1	Physical Interface	TH-ER-010

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 9 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	5.3.1.5.2	Fluid Use	
	5.3.1.5.2A	Fluid Use	TH-ER-010, MP-ER-001
	5.3.1.5.2B	Fluid Use	TH-ER-010, MP-ER-001
	5.3.1.5.2C	Fluid Use	TH-ER-010, MP-ER-001
	5.3.1.5.2D	Fluid Use	TH-ER-010
	5.3.1.5.2E	Fluid Use	TH-ER-010
	5.3.1.5.2F	Fluid Use	TH-ER-010
	5.3.1.5.3	Water Quantity	TH-ER-010
	5.3.1.5.4	Thermal Expansion	TH-ER-010
	5.3.1.5.5	Water Loop Pressure Drop	TH-ER-010
	5.3.1.5.6	Quick Disconnect (QD) Air Inclusion	TH-ER-010
	5.3.1.5.7	Leak Rate	TH-ER-010
	5.3.1.5.8	Water Coolant Flow Rate	TH-ER-010
	5.3.1.5.9	Water Coolant Supply Temperature	TH-ER-010
	5.3.1.5.10	Water Coolant Return Temperature	TH-ER-010
	5.3.1.5.11	Maximum Water Coolant System Pressure	TH-ER-010, ST-ER-010
	5.3.2	APM/JEM/CAM Unique Thermal Control Interface Requirements	TH-ER-015
NAR	5.4	Vacuum Exhaust Interface Requirements (USL, APM, JEM)	
	5.4.1	Physical Interface (USL, APM, JEM)	VC-ER-001
	5.4.2	Input Pressure Limit (USL, APM, JEM)	ST-ER-010, VC-ER-001
	5.4.3	Input Temperature Limit (USL, APM, JEM)	VC-ER-001
	5.4.4	Input Dewpoint Limit (USL, APM, JEM)	VC-ER-001
	5.4.5	Vacuum Exhaust System Maximum Design Pressure (MDP)	VC-ER-001
	5.4.6	Leak Rate (USL, APM, JEM)	VC-ER-001
	5.4.7	Acceptable Effluents (USL, APM, JEM)	VC-ER-001
NAR	5.4.7.1	Acceptable Gases (USL, APM, JEM)	
	5.4.7.1A	Acceptable Gases (USL, APM, JEM)	VC-ER-001
	5.4.7.1B	Acceptable Gases (USL, APM, JEM)	VC-ER-001

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 10 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	5.4.7.1C	Acceptable Gases (USL, APM, JEM)	VC-ER-001
	5.4.7.1D	Acceptable Gases (USL, APM, JEM)	VC-ER-001
	5.4.7.2	External Contamination Control (USL, APM, JEM)	VC-ER-001
NAR	5.4.7.3	Incompatible Exhaust Gases (USL, APM, JEM)	
	5.4.7.3A	Incompatible Exhaust Gases (USL, APM, JEM)	VC-ER-001
	5.4.7.3B	Incompatible Exhaust Gases (USL, APM, JEM)	VC-ER-001
	5.4.8	Utility Control	VC-ER-001
NAR	5.5	Gaseous Nitrogen (GN_2) Interface Requirements	
	5.5.1	Physical Interface	TH-ER-011
	5.5.2	Utility Control	TH-ER-011
	5.5.3	GN_2 System MDP	ST-ER-010, TH-ER-011
	5.5.4	Interface Pressure (USL, APM)	ST-ER-010, TH-ER-011
	5.5.5	Temperature	TH-ER-011
	5.5.6	Leak Rate	TH-ER-011
	5.5.7	GN_2 Characteristics	TH-ER-011
NAR	6.1	Electrical Power/Energy	
NAR	6.1.1	Baseline Power Allocation	
NAR	6.1.2	Shuttle/Middeck Power and Voltage	
NAR	6.2	EXPRESS Rack dc Power Characteristics	
NAR	6.2.1	28-Vdc Power and Voltage	
	6.2.1.1	Voltage Levels	EL-ER-001
NAR	6.2.1.2	Output Resistance	
	6.2.1.3	Reverse Current	EL-ER-003
	6.2.1.4	Reverse Energy	EL-ER-003
	6.2.1.5	Soft Start/Stop	EL-ER-004
NAR	6.2.2	Overload Protection	
	6.2.2.1	Overload Protection Device	EL-ER-005
	6.2.2.1.1	Device Accessibility	EL-ER-005
	6.2.2.1.2	Location	EL-ER-005
	6.2.2.1.3	Device Identification	EL-ER-005
	6.2.2.1.4	Extractor-Type Fuse Holder	EL-ER-005
NAR	6.2.3	Current Limiting	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 11 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	6.2.3A	Current Limiting	EL-ER-006
	6.2.3B	Current Limiting	EL-ER-006
	6.2.3C	Current Limiting	EL-ER-006
	6.2.3D	Current Limiting	EL-ER-006
NAR	6.3	Ripple and Transient Spike (Repetitive) Limits - Shuttle/Middeck	
NAR	6.3.1	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	
	6.3.1A	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	EL-MD-001
	6.3.1B	In-Flight dc Power Bus Ripple at the Interface - Shuttle/Middeck	EL-MD-001
	6.3.2	In-Flight dc Power Transient Spikes (Repetitive) - Shuttle/Middeck	EL-MD-001
	6.3.3	Ground dc Power - Shuttle/Middeck	EL-MD-002
NAR	6.3.3A	Ground dc Power - Shuttle/Middeck	
NAR	6.3.3B	Ground dc Power - Shuttle/Middeck	
NAR	6.3.3C	Ground dc Power - Shuttle/Middeck	
	6.3.4	Ac Power Characteristics - Shuttle/Middeck	EL-MD-003
	6.4	Ripple and Transient Spikes (Repetitive) Limits - ISS	EL-ER-007
	6.4.1	Startup Condition Spikes/Ripple	EL-ER-007
	6.4.2	Differential Mode PARD (Noise)	EL-ER-007
NAR	6.5	Limitations on EXPRESS Rack Payload Utilization of Electrical Power	
NAR	6.5.1	On-Orbit Transfer	
NAR	6.5.2	EXPRESS Rack Payload Electrical Safety/Hazards	
	6.5.2.1	Batteries	EL-ER-008
NAR	6.5.2.2	Safety-Critical Circuits	
	6.5.2.2A	Safety-Critical Circuits	EL-ER-009
	6.5.2.2B	Safety-Critical Circuits	EL-ER-009
	6.5.2.2C	Safety-Critical Circuits	EL-ER-009
NAR	6.5.2.3	Electrical Hazards	
NAR	6.5.2.3A	Electrical Hazards	
	6.5.2.3B	Electrical Hazards	EL-ER-010
	6.5.2.3C	Electrical Hazards	EL-ER-010

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 12 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	6.5.2.3D	Electrical Hazards	EL-ER-010
	6.5.2.3E	Electrical Hazards	EL-ER-010
	6.5.3	Power Loss	EL-ER-010
	6.5.3.1	Automatic Starting After Power Loss	EL-ER-010
	6.5.4	Emergency Operational Modes	EL-ER-010
	6.5.5	Payload Element Activation/Deactivation and Isolation	EL-ER-010
NAR	6.6	Electrical Connectors	
	6.6.1	Connector Pins/Sockets	EL-ER-011
	6.6.2	Electrical Connector Mating/Demating (Unpowered)	EL-ER-012
	6.6.3	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3A	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3B	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3B(1)	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3B(2)	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3B(3)	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.3B(4)	Electrical Connector Mating/Demating (Powered)	EL-ER-013
	6.6.4	Electrical Connector Mismating Prevention	EL-ER-014
	6.6.4A	Blind Connections/Disconnections	EL-ER-014
	6.6.4B	Mismating Damage	EL-ER-014
	6.6.4C	Other Payload Connections	EL-ER-014
	6.6.4D	Cable Labeling	EL-ER-014
	6.6.5	Mechanical Protection	EL-ER-011
	6.6.6	Power Connector/Front Panel Labeling	EL-ER-011
NAR	7.1	Circuit EMC Classifications	
NAR	7.2	Shuttle-Produced Interference Environment	
	7.2.1	Conducted Interference	EL-MD-001
	7.2.1.1	Shuttle-Produced WCCS Radiated Electric Fields	EL-MD-004
	7.2.2	Radiated Interference - Shuttle/Middeck	EL-MD-004
NAR	7.2.2A	Radiated Interference - Shuttle/Middeck	
	7.2.2B	Radiated Interference - Shuttle/Middeck	EL-MD-004
NAR	7.2.2C	Radiated Interference - Shuttle/Middeck	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 13 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	7.3	Electromagnetic Compatibility	EL-MD-004, EL-MD-005, EL-MD-006
	7.3.1	Emission and Susceptibility Limits and Test Methods	EL-ER-015, EL-ER-016
	7.3.1.1	Compatibility	EL-ER-015, EL-ER-016
NAR	7.3.1.2	Applicability	
	7.3.1.3	Conducted Emissions	EL-ER-015
NAR	7.3.1.3.1	CE01 Conducted Emissions	
	7.3.1.3.2	CE01 Limits	EL-ER-015
NAR	7.3.1.3.3	CE03 Conducted Emissions	
	7.3.1.3.4	CE03 Limits	EL-ER-015
NAR	7.3.1.3.5	CE07 Conducted Emissions	
	7.3.1.3.6	CE07 Limits	EL-ER-015
NAR	7.3.1.4	Conducted Susceptibility	
NAR	7.3.1.4.1	CS01 Conducted Susceptibility	
	7.3.1.4.2	CS01 Limits	EL-ER-016
NAR	7.3.1.4.3	CS02 Conducted Susceptibility	
	7.3.1.4.4	CS02 Limits	EL-ER-016
NAR	7.3.1.4.5	CS06 Conducted Susceptibility	
	7.3.1.4.6	CS06 Limits	EL-ER-016
NAR	7.3.1.4.6A	CS06 Limits	
NAR	7.3.1.4.6B	CS06 Limits	
NAR	7.3.1.5	Radiated Emissions	
NAR	7.3.1.5.1	RE02 Radiated Emissions	
NAR	7.3.1.5.2	Applicability	
	7.3.1.5.3	RE02 Limits	EL-ER-015
	7.3.1.5.4	Narrowband Electric Field Emissions	EL-ER-015
NAR	7.3.1.6	Radiated Susceptibility	
NAR	7.3.1.6.1	RS02 Radiated Susceptibility	
NAR	7.3.1.6.2	Applicability	
	7.3.1.6.3	RS02 Limits	EL-ER-016
NAR	7.3.1.6.3A	RS02 Limits	
NAR	7.3.1.6.3B	RS02 Limits	

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NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	7.3.1.7	RS03, Radiated Susceptibility	
NAR	7.3.1.7.1	Applicability	
	7.3.1.7.2	RS03 Limits	EL-ER-016
NAR	7.3.2	ESD	
	7.3.2.1	ESD Compatibility	EL-ER-017
	7.3.2.2	ESD Labeling	EL-ER-017
	7.3.2.3	Corona	EL-ER-018
NAR	7.4	Payload-Produced Interference Environment - Shuttle	
NAR	7.4.1	Payload-Produced Conducted Noise - Shuttle	
	7.4.1A	Payload-Produced Conducted Noise - Shuttle	EL-MD-005
	7.4.1B	Payload-Produced Conducted Noise - Shuttle	EL-MD-005
	7.4.1C	Payload-Produced Conducted Noise - Shuttle	EL-MD-005
NAR	7.4.2	Payload-Produced Radiated Fields - Shuttle	
	7.4.2A	Payload-Produced Radiated Fields - Shuttle	EL-MD-006
	7.4.2B	Payload-Produced Radiated Fields - Shuttle	EL-MD-006
	7.4.2C	Payload-Produced Radiated Fields - Shuttle	EL-MD-006
	7.4.2D	Payload-Produced Radiated Fields - Shuttle	EL-MD-006
NAR	7.4.3	Magnetic Fields for EXPRESS Rack Payloads in the ISS	
	7.4.3.1	ac Magnetic Fields for EXPRESS Rack Payloads in the ISS	EL-ER-019
	7.4.3.2	dc Magnetic Fields for EXPRESS Rack Payloads in the ISS	EL-ER-019
NAR	7.5	Avionics Electrical Compatibility - Shuttle and ISS	
	7.5.1	Electrical Bonding	EL-ER-020
	7.5.1A	Fault Current Bond - Class C	EL-ER-020
	7.5.1B	Shock Hazard - Class H	EL-ER-020
	7.5.1C	RF Bond - Class R	EL-ER-020
	7.5.1D	Static Bond - Class S	EL-ER-020
	7.5.1.1	Electrical Bonding of Payload Hardware	EL-ER-021
NAR	7.5.1.2	Electrical Bonding of Payload Structures	
NAR	7.5.1.2.1	Payload-to-EXPRESS Rack Main Bond	
	7.5.1.2.1.1	Primary Payload Power Connector Bond	EL-ER-022
	7.5.1.2.1.2	Payload-to-EXPRESS Rack Bond Strap	EL-ER-022

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 15 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	7.5.1.2.1.3	Payload-to-EXPRESS Rack Mated Surface Bond	EL-ER-022
NAR	7.5.1.2.2	Payload-to-EXPRESS Rack and Fluid Line Bonding	
NAR	7.5.2	Circuit Reference Symbols	
NAR	7.6	Power Circuit Isolation and Grounding	
	7.6.1	EXPRESS Rack 28-Vdc Primary Power Bus Isolation	EL-ER-023
NAR	7.6.2	dc Power Ground Reference	
	7.6.3	Payload Secondary Power Isolation and Grounding	EL-ER-023
	7.6.4	Ground Support Equipment (GSE) Isolation and Grounding	EL-ER-029
NAR	7.7	Signal Isolation and Grounding Requirements	
	7.7.1	Ethernet	EL-ER-024
	7.7.2	RS-422	EL-ER-024
	7.7.3	Solid State Power Controller Module (SSPCM) Analog Grounding	EL-ER-024
	7.7.4	SSPCM Discrete	EL-ER-024
	7.7.5	Video	EL-ER-024
	7.7.6	Shield References	EL-ER-024
NAR	8.1	General	
NAR	8.1.1	Connector/Pin Interfaces	
	8.1.1.1	MDLs/MDL Replacement	EL-ER-026
	8.1.1.1.1	Previously Flown (Shuttle) MDLs/MDL Replacement	EL-ER-026
	8.1.1.2	ISIS Drawers	EL-ER-026
	8.1.2	Approved Connectors for EXPRESS Rack Payload Use	EL-ER-027
NAR	8.2	Cable Schematics	
NAR	9.1	RS-422 Communications	
	9.1.1	Signal Characteristics	CD-ER-001
	9.1.2	Telemetry Format	CD-ER-001
	9.1.3	Request/Command Format	CD-ER-001
	9.1.4	Processing Requirements	CD-ER-001
NAR	9.1.5	Connector/Pin Interface	
	9.1.5.1	MDLs/MDL Replacements	CD-ER-002
	9.1.5.2	ISIS Drawers	CD-ER-002
NAR	9.2	Ethernet Communications	
	9.2.1	Signal Characteristics	CD-ER-003
	9.2.2	Communications Protocol	CD-ER-003

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 16 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	9.2.3	Telemetry Format	CD-ER-003
	9.2.4	Request/Command Format	CD-ER-003
	9.2.5	Processing Requirements	CD-ER-003
NAR	9.2.6	Connector/Pin Interface	
	9.2.6.1	MDLs/MDL Replacements	CD-ER-002
	9.2.6.2	ISIS Drawers	CD-ER-002
NAR	9.2.7	Communications to Laptop	
NAR	9.3	Analog Communications	
	9.3.1	Signal Characteristics	CD-ER-004
	9.3.2	Analog Driver Characteristics	CD-ER-004
NAR	9.3.3	Connector/Pin Interface	
	9.3.3.1	MDLs/MDL Replacement	CD-ER-002
	9.3.3.2	ISIS Drawers	CD-ER-002
NAR	9.4	Discrete Communications	
NAR	9.4.1	Discrete Signal Characteristics	
	9.4.1.1	Discrete Output Low Level	CD-ER-005
	9.4.1.2	Discrete Output High Level	CD-ER-005
	9.4.1.3	Discrete Output Maximum Fault Current	CD-ER-005
	9.4.1.4	Discrete Input Low Level	CD-ER-005
	9.4.1.5	Discrete Input High Level	CD-ER-005
	9.4.1.6	Discrete Input Maximum Fault Voltage	CD-ER-005
	9.4.2	Discrete Driver and Receiver Characteristics	CD-ER-006
NAR	9.4.3	Connector/Pin Interface	
	9.4.3.1	MDLs/MDL Replacement	CD-ER-002
	9.4.3.2	ISIS Drawers	CD-ER-002
	9.5	Continuity Discrete Jumper	CD-ER-002
	9.6	Point-to-Point Communications Bus (PPCB)	CD-ER-002
	9.7	Video	CD-ER-007
NAR	9.7.1	Payload National Television Standards Committee (NTSC) Video Characteristics	
	9.7.1.1	Input Impedance	CD-ER-007
	9.7.1.2	Sync Tip	CD-ER-007
	9.7.1.3	Blanking Level	CD-ER-007
	9.7.1.4	White Reference	CD-ER-007
NAR	9.7.2	Deviations to Video Standard	

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NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	9.7.2A	Deviations to Video Standard	
NAR	9.7.2B	Deviations to Video Standard	
NAR	9.7.2C	Deviations to Video Standard	
NAR	9.7.2D	Deviations to Video Standard	
NAR	9.7.2E	Deviations to Video Standard	
	9.7.3	Connector/Pin Interface	CD-ER-002
NAR	10.1	Payload Equipment Surface Cleanliness	
	10.1A	Payload Equipment Surface Cleanliness	MP-ER-001
	10.1B	Payload Equipment Surface Cleanliness	MP-ER-001
NAR	10.2	Illumination Requirements - Lighting Design	
	10.2.1	Work Surface Specularity	EN-ER-001
	10.2.2	Supplemental Lighting	EN-ER-001
	10.2.3	Direct Light Sources	EN-ER-001
	10.2.4	Glovebox Lighting	EN-ER-001
	10.2.5	Portable Utility Lighting	EN-ER-001
NAR	10.3	Laser Requirements	
	10.3.1	Laser Design and Operation in Compliance with ANSI Standard Z136.1-1993	EN-ER-002
	10.3.2	Non-Ionizing Radiation	EN-ER-002
	10.3.3	Safe Operation	EN-ER-002
	10.3.4	Accidental Exposures	EN-ER-002
	10.3.5	Laser and Optical Radiation Monitoring	EN-ER-002
	10.3.6	Personnel Protection Devices	EN-ER-002
NAR	10.4	Radiation Requirements	
	10.4.1	Payload Contained or Generated Ionizing Radiation	EN-ER-003
	10.4.2	Single Event Effect (SEE) Ionizing Radiation	EN-ER-003
	10.4.3	Radiation Dose Requirements	EN-ER-003
NAR	10.5	Atmosphere Requirements	
	10.5.1	Oxygen Consumption	EN-ER-004
	10.5.2	Chemical Releases	EN-ER-004
NAR	11.1	Laptop Computers	
	11.1.1	Payload and General Support Computer	SW-ER-001
NAR	11.1.1.1	PGSC Electrical Power Characteristics	
NAR	11.1.1.1.1	Payload-Powered PGSC	
NAR	11.1.1.1.2	Orbiter-Powered PGSC	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 18 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	11.1.1.2	PGSC Communication/Power Interfaces Cables	
	11.1.1.2.1	RS-232 Communication Cables (Orbiter PGSC)	SW-ER-001
	11.1.1.2.2	RS-422 Communication Cables (Orbiter PGSC)	SW-ER-001
	11.1.1.2.3	Power Cables (Orbiter PGSC)	SW-ER-001
	11.1.1.3	Software (Orbiter PGSC)	SW-ER-002
NAR	11.1.2	EXPRESS Rack Laptop (A-I)	
	11.1.3	ISS Portable Computer System	SW-ER-005
NAR	11.2	EXPRESS Rack Software	
	11.2.1	EXPRESS Rack PEHB Interface (Ethernet)	SW-ER-004
NAR	11.2.1A	ISS Payload Ethernet Hub/Gateway Interfaces	
NAR	11.2.1B	Laptop Ethernet Interface	
NAR	11.2.1B(1)	Laptop Ethernet Interface	
NAR	11.2.1B(2)	Laptop Ethernet Interface	
NAR	11.2.1C	Payload Ethernet Interface	
NAR	11.2.1C(1)	Payload Ethernet Interface	
NAR	11.2.1C(2)	Payload Ethernet Interface	
NAR	11.2.1C(3)	Payload Ethernet Interface	
	11.2.2	EXPRESS Rack RIC Serial Interface (RS-422)	SW-ER-003
NAR	11.2.3	Payload Interface Data Elements	
	11.2.3.1	EXPRESS Header	SW-ER-003, SW-ER-004
NAR	11.2.3.2	Unique Identifier Numbers	
	11.2.3.3	EXPRESS Telemetry Header	SW-ER-003, SW-ER-004
	11.2.3.4	Payload Telemetry Packet	SW-ER-003, SW-ER-004
	11.2.3.5	EXPRESS RIC Interface Requests and Responses	CD-ER-001, CD-ER-003, SW-ER-003, SW-ER-004
NAR	11.2.3.5.1	Payload Executive Processor (PEP) Bundle Request	
NAR	11.2.3.5.2	PEP Procedure Execution	
NAR	11.2.3.5.3	Rack Time Request	
NAR	11.2.3.5.4	Ancillary Data Configuration Control	

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 19 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	11.2.3.5.5	File Transfer	CD-ER-001, CD-ER-003, SW-ER-003, SW-ER-004, SW-ER-007
NAR	11.2.3.5.5.1	Payload File Transfer	
NAR	11.2.3.5.5.2	EXPRESS Memory Unit (EMU) File Transfer	
NAR	11.2.3.5.6	Payload Response	
	11.2.3.6	Payload Health and Status Data	SW-ER-003, SW-ER-004
	11.2.3.7	EXPRESS Payload Commanding	CD-ER-001, CD-ER-003, SW-ER-003, SW-ER-004, SW-ER-008
	11.2.4	Laptop Computer Software Configuration Item (CSCI) Interfaces	SW-ER-004
NAR	11.2.4.1	Laptop Data Elements	
	11.2.4.2	Payload-Provided Software/Peripherals	SW-ER-007
	11.2.4.3	EXPRESS Rack Laptop Display Requirements	SW-ER-007
NAR	11.2.4.4	Payload Software Interfaces	
	11.2.4.4A	Laptop Communications	SW-ER-004, SW-ER-007
NAR	11.2.4.4B	Software Updating Process for Laptop	
	11.2.4.4C	Payload Application Winsock	SW-ER-004, SW-ER-007
	11.2.4.5	File Maintenance	SW-ER-007
	11.3	Software Safety Requirements for Payloads	SW-ER-006
NAR	12.1	Portable Item Handles/Grasp Areas/Temporary Stowage Restraints	
	12.1.1	Provide Handles and Restraints	HF-ER-001
	12.1.2	Handle Location	HF-ER-001
	12.1.3	Handle Dimensions	HF-ER-001
	12.1.4	Handle Clearance	HF-ER-001
NAR	12.1.5	Non-Fixed Handles Design Requirements	
	12.1.5A	Non-Fixed Handles Design Requirements	HF-ER-001
	12.1.5B	Non-Fixed Handles Design Requirements	HF-ER-001

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 20 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	12.1.5C	Non-Fixed Handles Design Requirements	HF-ER-001
	12.1.6	Tether Points	HF-ER-001
	12.1.7	Captive Parts	HF-ER-001
	12.1.8	Temporary Stowage/Placement	HF-ER-001
NAR	12.2	Strength Requirements	
NAR	12.2A	Strength Requirements	
	12.2A(1)	Grip Strength	HF-ER-002
	12.2A(2)	Linear Forces	HF-ER-002
	12.2A(3)	Torques	HF-ER-002
	12.2B	Strength Requirements	HF-ER-002
NAR	12.3	Body Envelope and Reach Accessibility	
	12.3.1	Operational Volume	HF-ER-003
NAR	12.3.2	Accessibility	
TBD-ISS	12.3.2A	Accessibility	HF-ER-003, (**TBD#34**)
	12.3.2B	Accessibility	HF-ER-003
	12.3.3	Full Size Range Accommodation	HF-ER-003
NAR	12.4	Payload Hardware Mounting	
	12.4.1	Equipment Mounting	HF-ER-004
	12.4.2	Drawers and Hinged Panels	HF-ER-005
	12.4.3	Alignment	HF-ER-006
	12.4.4	Slide-Out Stops	HF-ER-007
	12.4.5	Push-Pull Force	HF-ER-002
	12.4.6	Access	HF-ER-008
NAR	12.4.6.1	Covers	
	12.4.6.1A	Covers	HF-ER-008
	12.4.6.1B	Covers	HF-ER-008
	12.4.6.1C	Covers	HF-ER-008
	12.4.6.2	Self-Supporting Covers	HF-ER-008
	12.5	Identification Labeling	HF-ER-011, HF-ER-039
	12.5.1	Color	HF-ER-014
	12.5.2	Fluid Connector Pressure/Flow Indicators	HF-ER-015
NAR	12.5.3	Coding	
	12.5.3A	Coding	HF-ER-006

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 21 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	12.5.3B	Coding	HF-ER-006
	12.5.4	Pin Identification	HF-ER-023
NAR	12.6	Controls and Displays	
	12.6.1	Controls Spacing Design Requirements	HF-ER-017
NAR	12.6.2	Accidental Actuation	
	12.6.2.1	Protective Methods	HF-ER-018
NAR	12.6.2.1A	Protective Methods	
	12.6.2.1B	Protective Methods	HF-ER-018
	12.6.2.1C	Protective Methods	HF-ER-018
	12.6.2.1D	Protective Methods	HF-ER-018
NAR	12.6.2.1E	Protective Methods	
NAR	12.6.2.1F	Protective Methods	
NAR	12.6.2.1G	Protective Methods	
	12.6.2.2	Noninterference	HF-ER-017
NAR	12.6.2.3	Dead-Man Controls	
	12.6.2.4	Barrier Guards	HF-ER-017
	12.6.2.5	Recessed Switch Protection	HF-ER-018
	12.6.2.6	Position Indication	HF-ER-018
	12.6.2.7	Hidden Controls	HF-ER-018
	12.6.2.8	Hand Controllers	HF-ER-018
NAR	12.6.3	Valve Controls	
	12.6.3A	Valve Controls (Low-Torque Valves)	HF-ER-019
	12.6.3B	Valve Controls (Intermediate-Torque Valves)	HF-ER-019
	12.6.3C	Valve Controls (High-Torque Valves)	HF-ER-019
	12.6.3D	Valve Controls (Handle Dimensions)	HF-ER-019
	12.6.3E	Valve Controls (Rotary Valve Controls)	HF-ER-019
	12.6.4	Toggle Switches	HF-ER-020
NAR	12.6.5	Stowage and Equipment Drawers/Trays	
	12.6.5A	Stowage and Equipment Drawers/Trays	HF-ER-032
	12.6.5B	Stowage and Equipment Drawers/Trays	HF-ER-032
NAR	12.6.6	Audio Devices (Displays)	
	12.6.6A	Audio Devices (Displays)	HF-ER-021
	12.6.6B	Audio Devices (Displays)	HF-ER-021
	12.6.6C	Audio Devices (Displays)	HF-ER-021

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 22 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
NAR	12.7	Electrical Connector Design - General	
	12.7.1	Mismatched	EL-ER-014
	12.7.2	Connector Protection	HF-ER-023
	12.7.3	Arc Containment	EL-ER-013, HF-ER-023
NAR	12.7.4	Connector Arrangement	
	12.7.4A	Connector Arrangement	HF-ER-024
	12.7.4B	Connector Arrangement	HF-ER-024
	12.7.5	One-Handed Operation	HF-ER-022
NAR	12.7.6	Accessibility	
NAR	12.7.6A	Mate/Demate	
	12.7.6A(1)	Nominal Operations	HF-ER-022
	12.7.6A(2)	Maintenance Operations	HF-ER-022
	12.7.6B	Accessibility	HF-ER-022
NAR	12.7.7	Ease of Disconnect	
	12.7.7A	Ease of Disconnect	HF-ER-022
	12.7.7B	Ease of Disconnect	HF-ER-022
	12.7.8	Self-Locking	HF-ER-022
	12.7.9	Connector Shape	HF-ER-023
	12.7.10	Fluid and Gas Line Connectors	HF-ER-015
	12.7.11	Fluid and Gas Line Connectors Mating	HF-ER-015
	12.7.12	Alignment Marks or Guide Pins	HF-ER-006
	12.7.13	Orientation	HF-ER-024
NAR	12.8	Hose/Cable Restraints	
	12.8A	Hose/Cable Restraints	HF-ER-025
	12.8B	Hose/Cable Restraints	HF-ER-025
	12.8C	Hose/Cable Restraints	HF-ER-025
NAR	12.9	Habitability/Housekeeping	
	12.9.1	Closures or Covers	HF-ER-008
NAR	12.9.2	Built-In Control	
	12.9.2A	Built-In Control	HF-ER-026
	12.9.2B	Built-In Control	HF-ER-026
	12.9.3	One-Handed Operation	HF-ER-027

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NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	12.10	Waste Management	HF-ER-028 (**TBD#24**)
	12.11	Mechanical Energy Devices	HF-ER-029
NAR	12.12	Fasteners	
	12.12.1	Non-Threaded Fasteners	HF-ER-030
	12.12.2	Mounting Bolt/Fastener Spacing	HF-ER-031
	12.12.3	Multiple Fasteners	HF-ER-031
	12.12.4	Captive Fasteners	HF-ER-031
NAR	12.12.5	Quick Release Fasteners	
	12.12.5A	Quick Release Fasteners	HF-ER-030
	12.12.5B	Quick Release Fasteners	HF-ER-030
	12.12.6	Threaded Fasteners	HF-ER-031
NAR	12.12.7	Over Center Latches	
	12.12.7A	Over Center Latches (Non-Self-Latching)	HF-ER-032
	12.12.7B	Over Center Latches (Latch Lock)	HF-ER-032
	12.12.7C	Over Center Latches (Latch Handles)	HF-ER-032
	12.12.8	Winghead Fasteners	HF-ER-030
NAR	12.12.9	Fastener Head Type	
	12.12.9A	Fastener Head Type	HF-ER-031
	12.12.9B	Fastener Head Type	HF-ER-031
	12.12.9C	Fastener Head Type	HF-ER-031
	12.12.10	One-Handed Actuation	HF-ER-031
	12.12.11	Accessibility	HF-ER-031
	12.12.12	Access Holes	HF-ER-008
	12.13	Payload In-Flight Maintenance	HF-ER-033
	13.1	Materials and Processes Use and Selection	ME-ER-001
	13.1.1	Acceptance Criteria for Stress Corrosion Cracking (SCC)	MP-ER-001
	13.1.2	Hazardous Materials and Compatibility	MP-ER-001
	13.1.3	Test and Acceptance Criteria for Flammability	MP-ER-001
	13.1.4	Test and Acceptance Criteria for Toxic Offgassing (Toxicity)	MP-ER-001
	13.2	Galvanic Corrosion	MP-ER-001
	13.3	Fungus-Resistant Material	MP-ER-001
	13.4	Materials and Parts Certification and Traceability	MP-ER-001

TABLE B-I IDD REQUIREMENT CROSS REFERENCE (Sheet 24 of 24)

NOTE/ DISPOSITION	IDD RQMT NO.	IDD REQUIREMENT TITLE	VRDS NO.
	14.1	Fire Event Prevention Requirements	FP-ER-001
	14.1.1	Flammability Requirements	MP-ER-001 (6)
NAR	14.1.2	Oxygen	
	14.1.2A	Oxygen	FP-ER-002
	14.1.2B	Oxygen	FP-ER-002
	14.1.2C	Oxygen	FP-ER-002
NAR	14.1.3	Electrical Systems	
	14.1.4	Payload Use of Battery Backup Power	FP-ER-003
NAR	14.1.4A	Payload Use of Battery Backup Power	
NAR	14.1.4B	Payload Use of Battery Backup Power	
	14.2	Payload Data Monitoring	FP-ER-004
	14.2A	Crew Notification	FP-ER-004
	14.2B	Payload Location Identification	FP-ER-004
	14.2C	Emergency, Caution, Warning (ECW) Word (0, 1, 3)	FP-ER-004
NAR	14.2C(1)	ECW Word 0	
NAR	14.2C(2)	ECW Word 1	
NAR	14.2C(3)	ECW Word 3	
NAR	14.2.1	Fire Event Location Indicator	
NAR	14.2.1A	Fire Event Location Indicator	
NAR	14.2.1B	Fire Event Location Indicator	
NAR	14.3	PFE Access Port Requirements	
NAR	14.3A	PFE Access Port Requirements	
NAR	14.3B	PFE Access Port Requirements	
	14.3C	PFE Access Port Requirements	FP-ER-005
	14.3D	PFE Access Port Requirements	FP-ER-005
	14.3E	PFE Access Port Requirements	FP-ER-005
	14.3.1	PFE Characteristics	FP-ER-005
	14.3.2	PFE Port Dimensions	FP-ER-005
	14.3.3	Fire Suppression Port Access	FP-ER-005
	14.3.4	Fire Access Port Quantity	FP-ER-005
	14.3.5	PFE Closeouts	FP-ER-005
	14.4	Fire Suppressant Distribution	FP-ER-006

APPENDIX C

ABBREVIATIONS AND ACRONYMS

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APPENDIX C, ABBREVIATIONS AND ACRONYMS

10BASE-T	Ethernet Protocol Implementation
A	Amp, Ampere, or Analysis
AAA	Avionics Air Assembly
ac	Alternating Current
ANSI	American National Standards Institute
APM	Attached Pressurized Module
ARIS	Active Rack Isolation System
°C	Degrees Celsius
C&DH	Command and Data Handling
C&W	Caution and Warning
CAM	Centrifuge Accommodations Module
CB	Control Board
cc	Cubic Centimeters
cfm	Cubic Feet per Minute
CG	Center of Gravity
cm	Centimeter
CM	Crew Module
CO_2	Carbon Dioxide
COC	Certificate of Compliance
COF	Columbus Orbiting Facility
CoFR	Certificate of Flight Readiness
COU	Concept of Operation and Utilization
CR	Change Request
CSCI	Computer Software Configuration Item
D	Demonstration
dB	Decibel
dBpT	Decibel Picotesla
dc	Direct Current
DCB	Development Control Board
DFRC	Dryden Flight Research Center
DQA	Data Quality Assurance; Document Quality Assurance
DRR	Document Release Record
ECW	Emergency, Caution, Warning
e.g.	exempli gratia (for example)
EI	Engineering Integration

EIA	Electronic Industries Association or EXPRESS Integration Agreement
EIRR	EXPRESS Integration Readiness Review
EL	Electrical
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMU	EXPRESS Memory Unit
EN	Environment
EPIM	EXPRESS Payload Integration Manager
ER	EXPRESS Rack
ERO	EXPRESS Rack Office
ERP	EXPRESS Rack Payload
ESD	Electrostatic Discharge
etc.	et cetera
ETR	EXPRESS Transportation Rack
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
°F	Degrees Fahrenheit
FCU	Functional Check-Out Unit
ft	Foot
ft^2	Square Foot
ft^3	Cubic Foot
g	Gravity
GFE	Government-Furnished Equipment
GHe	Gaseous Helium
GN_2	Gaseous Nitrogen
GPVP	Generic Payload Verification Plan
GSE	Ground Support Equipment
HB	Handbook
HDBK	Handbook
HF	Human Factors
hr	Hour(s)
I	Inspection
I/O	Input/Output
ICD	Interface Control Document
ID	Identification
IDD	Interface Definition Document
i.e.	id est (that is)
in	Inch
in^2	Square Inch
in-lb	Inch Pound

IP	International Partner
ISIS	International Subrack Interface Standard
ISPR	International Standard Payload Rack
ISS	International Space Station
IVA	Intravehicular Activity
JEM	Japanese Experiment Module
JMICB	Joint Mission Integration Control Board
JPRCB	Joint Program Review Control Board
JSC	Johnson Space Center
kg	Kilogram
KHB	Kennedy Handbook
kHz	Kilohertz (kilocycles per second)
kPa	KiloPascal
KSC	Kennedy Space Center
kW	Kilowatt
L	Launch
lb	Pound
lbf	Pound Force
lbm	Pound Mass
m	Meter
mA	Milliampere
MA	Materials
MD	Middeck
MDL	Middeck Locker
MDP	Maximum Design Pressure
ME	Mechanical
MHz	Megahertz
MIL	Military
min	Minute
mm	Millimeter
MP	Materials and Parts
MPCIB	Multilateral Payload Interface Control Board
MPLM	Multipurpose Logistics Module
ms	Millisecond
MSFC	Marshall Space Flight Center
MUA	Material Usage Agreement
mV	Millivolt

N	Newton
N-m	Newton-meter
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
nF	Nanofarad
ns	Nanosecond
NSTS	National Space Transportation System
NTSC	National Television Standards Committee
O&U	Operations and Utilization
O_2	Oxygen
ORU	Orbital Replacement Unit
P/N	Part Number
PAH	Payload Accommodations Handbook
par	Paragraph
PCB	Payload Control Board
PCS	Portable Computer System
PD	Payload Developer
PDL	Payload Data Library
PEHB	Payload Ethernet Hub/Bridge
PEP	Payload Executive Processor
PFE	Portable Fire Extinguisher
PGSC	Payload and General Support Computer
PIA	Payload Integration Agreement
PPCB	Point-to-Point Communication Bus
psi	Pounds per Square Inch
psia	Pounds per square Inch Absolute
psid	Pounds per Square Inch Differential
psig	Pounds per Square Inch Gauge
PSRP	Payload Safety Review Panel
pT	Picotesla
PTR	PIRN Technical Review
PU	Panel Unit
PVC	Polyvinalchloride
PVP	Payload Verification Plan
PVPP	Payload Verification Program Plan
PWL	Sound Power Level
PWQ	Process Waste Questionaire
QD	Quick Disconnect

Rev	Revision
RF	Radio Frequency
RIC	Rack Interface Controller
S	Safety
SA	Safety
scc	Standard Cubic Centimeters
SCC	Stress Corrosion Cracking
ScS	Suitcase Simulator
sec	Second or Section
SG	Stowage
SHR	Safety Hazard Report
SIR	Standard Interface Rack
SLM	Sound Level Meter
SPEC	Specification
SPL	Sound Pressure Level
SSP	Space Station Program
SSPC	Solid-State Power Controller
SSPCM	Solid-State Power Controller Module
ST	Structures
STD	Standard
STS	Space Transportation System
SW	Software
T	Test
TBD	To Be Determined
TCP/IP	Transmission Control Protocol/Internet Protocol
Temp	Temperature
TH	Thermal
U.S.	United States
USL	United States Laboratory
V	Volt
VC	Vacuum
VC-S	Visibly Clean-Sensitive
Vdc	Volts Direct Current
vol	Volume
VRDS	Verification Requirement Definition Sheet
W	Watt

ΔP	Delta Pressure
µ	Micron
µF	Microfarad
µg	Microgravity
µs	Microsecond

APPENDIX D

GLOSSARY OF TERMS

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APPENDIX D, GLOSSARY OF TERMS

Agreement - A documented recognition of the mutually agreed-to requirements imposed on the ISSP and the Customer, pertaining to the eventual integration and operation of the Customer's payload on board the ISS. (e.g., PIA, EIA)

Blank Book - A document consisting of instructions, examples, and forms for generating another document. (e.g., PDSBB, GPVP)

Certified (Cert) Data - That verification data as documented on the specific VRDS to which both PD and ISSP have made an agreement that this data, properly attained verified, and rectified will satisfy a specific verification requirement.

Customer - The organization responsible for overall design, fabrication, integration, and operation of the sub-rack payload. The organization is assumed to include such people as program manager, PD, principal investigator, and possibly sponsor. Integration activities include assuring the ISSP that the payload will physically fit and safely reside on board the ISS, in all required transport vehicles, and in all required ground facilities; coordinating with the ISSP for planning of payload operations, especially those involving shared ISS resources (e.g., power, crew, fluids, data, etc.); and coordinating with the ISSP for training of all required personnel (ISS, flight, integration, and ground support). Operations activities include coordinating with the ISSP during nominal and off-nominal operation of the payload on board the ISS.

Customer-Provided - Provided by the Customer for its own use on the ground and/or in space. Customer-provided items to be integrated with any ISSP items must be approved by the ISSP.

EXPRESS Rack - An ISPR with additional hardware for accommodating small sub-rack payloads, such as those in Shuttle MDLs and ISIS drawers. The EXPRESS Rack accommodates eight MDLs and two 4-PU ISIS drawers. One type of EXPRESS Rack is outfitted with ARIS and the other type does not have ARIS.

Experiment - An activity performed using a payload, with or without human assistance.

Increment - A variable block of time used by the ISSP for grouping activities to be performed on board the ISS. The length of an Increment will be set to the time between two designated Earth-to-orbit vehicle flights, and typically will vary between 2 and 4 months, once payload operations begin.

International Space Station - The first space station to be comprised of major elements from many nations, including the United States, Russia, Europe, Japan, Canada, and

Italy. The ISS is a place for humans to perform scientific and commercial research to improve the lives of others on Earth and in space.

International Space Station Program - The international organization responsible for ISS design, construction, operation, and utilization. The latter consists of payload integration and payload operations.

ISSP-Provided - Provided by the ISSP to the Customer for use on the ground and/or in space. ISSP-provided items are provided only on Customer request, and usually for a fee.

Payload - The collection of hardware (including structure), replacement parts, software, support equipment, and/or specimens provided by the Customer to the ISSP for transport to and from the ISS, and for installation and operation once on board. The collection is defined by the Customer and documented in their PIA and inputs to the PDL-resident data sets. The payload can be any size or shape, ranging from one that could fit in a stowage drawer or middeck locker location, to one that occupies several rack locations (see **facility-class payload**) or an entire external pallet. A change to the payload may require a revision to the PIA and the submitted technical data. The ISSP will treat the payload as a single entity except in those instances where parts of the payload must be handled separately by ISSP personnel.

Payload Container - Any structure designed as an enclosure for a payload or multiple payload items that are intended to be ultimately installed into a pressurized element rack, i.e., drawers and lockers used for stowage racks and EXPRESS Rack payloads.

Payload Data Library - An interactive database program for collecting and managing PIA and technical data from all Customers, and sharing them among the other ISSP functions and databases.

Pressurized Payload - A payload placed on board the ISS inside a pressurized module (e.g., USL, APM, JEM, or Centrifuge Module).

APPENDIX E

EXAMPLE SUBMITTAL FORMS

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CERTIFICATE OF COMPLIANCE (COC)

I hereby certify compliance with the verification requirements as specified in ____________________. I also certify the identified as-built hardware, per the current applicable Engineering Configuration List, was manufactured in accordance with the design drawings, parts lists, applicable waivers, and deviations. All supporting data is valid, applicable, and complete. This data is maintained in our files and will be made available upon request.

PAYLOAD	VRDS NUMBER	METHOD	APPLICABLE DOCUMENT REV. DATE	DRAWINGS, PARTS LISTS, WAIVERS, PROCEDURES, ETC. (ATTACH CORRELATED LIST AS NEEDED)

____
Print Name/Signature/Date
Payload Developer Responsible Person
Organization

DATA CERTIFICATION

I hereby certify compliance with the verification requirements as specified in ______________________. I also certify the identified as-built hardware, per the current applicable Engineering Configuration List, was manufactured in accordance with the design drawings, parts lists, applicable waivers, and deviations. All supporting data is valid, applicable, and complete. This data is maintained in our files and will be made available upon request.

PAYLOAD	VRDS NUMBER	METHOD	APPLICABLE DOCUMENT REV. DATE	COMPLETION DATE	SUMMARY (ATTACH SHEETS AS NEEDED)

____
Print Name/Signature/Date
Payload Developer Responsible Person
Organization

VERIFICATION ANALYSIS REPORT			
Payload:	Analyst:	Configuration Analyzed:	Date:
1. Objective of the Analysis:			
2. Requirements Satisfied:			
3. Description of Analytical Technique (Attach additional sheets as required):			
4. Analysis Input Data (Summary):			
5. Technical Results (Attach additional sheets as required):			
6. Conclusions (Attach additional sheets as required):			
7. Signature and Organization:			

VERIFICATION TEST REPORT			
Payload:	Test Engineer:	Test Procedure Used:	Date:
1. Item Tested (Name, Serial Number, Part Number):			
2. Objectives of the Test (Attach additional sheets as required):			
3. Description of Test Setup (Attached additional sheets as required):			
4. Test Results Summary (Attached additional sheets as required):			
5. Correlation of Test Sequence to Verification Requirements (Attach additional sheets as required):			
6. Explanation of all Failures and Corrective Action Taken During the Test (Attach additional sheets as required):			
7. Signature and Organization:		7. Quality Assurance:	

SAMPLE *[Project Unique Identifier]*

[Payload Name]

EXPRESS REQUIREMENTS CHANGE ASSESSMENT REPORT

Applicability: Stage *[Applicable Stage Number]*
I hereby certify that:

1. All requirements in the *[Payload Name]* Interface Control Document and Payload Verification Plan have been satisfied. The *[Payload Name]* Interface Control Document, SSP 52XXX-ICD and Payload Verification Plan, SSP 52XXX-PVP are consistent with the EXPRESS Rack Interface Definition Document, SSP 52000-IDD-ERP Issue *[Issue Letter]*.

2. All Program requirements changes listed in Table E-I have been assessed and that the *[Payload Name]* hardware complies with the modified requirements except where exceptions have been approved by the ERO, SSP and/or ISS Payloads Office as noted in Table E-I. Based upon the *[Payload Name]* Interface Control Document and Payload Verification Plan, this EXPRESS Requirmeents Change Assessment Report, and reports [Project Unique Identifier(s)] the *[Payload Name]* hardware complies with the Stage Requirements Set defined in *[CoFR letter memo number]*.

TABLE E-I ASSESSED PROGRAM REQUIREMENTS CHANGES

CHANGE NUMBER	CHANGE TITLE	COMPLY	EXCEPTION
57000-NA-0193	Revise limit on payload pressurized gas bottle flow rate	X	
57000-NA-0194	Add MDP to payload allowable leak rate for gases supplied to payloads		X
57000-ES-0001	Addition ISS Configuration Management Requirements	X	
57000-NA-0024	Correct Length Inequality	X	
57000-NA-0161	Magnetic Fields Requirements Update	X	

A summary of the assessment performed for each of the identified changes is provided in Table E-II. The additional verification data generated as a result of these changes are provided as attachments to this report.

[Signature of Project Manager]

TABLE E-II CHANGE ASSESSMENT SUMMARY

CHANGE NUMBER	ASSESSMENT SUMMARY
57000-NA-0193	A flow restrictor was incorporated into the design of the GASMAP gas bottles to prevent leakage from the bottles exceeding the defined value.
57000-NA-0194	Review of leak test data shows that the leak rate of the HRF N_2 system was measured at a pressure 0.5 psi below the defined MDP. Exception 57000-NA-0101 was approved and documents that this condition is acceptable as is.
57000-ES-0001	This change is N/A to the design of the HRF hardware; it affects the process by which documentation is reviewed and approved only.
57000-NA-0024	This change is N/A to the design of the HRF hardware; it is an editorial correction of the allowable MRDL cable length.
57000-NA-0161	A magnetic fields emission test was performed per this change and the test results were below the specified limits. Test report HRF-EMC-0013 is provided as Attachment 1.

SAMPLE *[Project Unique Identifier]*
[Date]

Attachment 1
HFR-EMC-0013
AC/DC Magnetic Fields Emission Test for the HFR Rack 1

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APPENDIX F

VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS)

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TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 1 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
CD-ER-001	9.1.1	RS-422 Signal Characteristics	T	See Note	See Note	ScS can provide a demonstration of a nominal (electrical) test case for communicating via an RS-422 Interface.
CD-ER-001	9.1.2	RS-422 Telemetry Format	T	See Note	See Note	ScS will process telemetry data, and capture it for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
CD-ER-001	9.1.3	RS-422 Request/ Command Format	T	See Note	See Note	ScS will process payload requests and issue commands, and capture this data for logging and display. Verify by real-time error reporting of request/command format problems and post-test analysis of logged data.
CD-ER-001	9.1.4	RS-422 Processing Requirements	T	See Note	See Note	ScS will process payload requests and issue commands, and capture this data for logging and display. Verify by real-time error reporting of request/command format problems and post-test analysis of logged data.
CD-ER-002	9.1.5.1	RS-422 MDLs/MDL Replacements Connector/ Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.
CD-ER-002	9.1.5.2	RS-422 ISIS Drawers Connector/Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.
CD-ER-003	9.2.1	Ethernet Signal Characteristics	T	See Note	See Note	ScS can provide a demonstration or a nominal (electrical) test case for communicating via an Ethernet interface.

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 2 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
CD-ER-003	9.2.2	Ethernet (TCP/IP) Communications Protocol	T	See Note	See Note	ScS will process RIC to/from payload communications via Transmission Control Protocol/Internet Protocol (TCP/IP), capture this data and response data for logging and display. Verify by real-time error reporting of communication problems and post-test analysis of logged data.
CD-ER-003	9.2.3	Ethernet Telemetry Format	T	See Note	See Note	ScS will process telemetry data, and capture this data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
CD-ER-003	9.2.4	Ethernet Request/ Command Format	T	See Note	See Note	ScS will process payload requests and issue commands, capture this data and response data for logging and display. Verify by real-time error reporting of request/command format problems and post-test analysis of logged data.
CD-ER-003	9.2.5	Ethernet Processing Requirements	T	See Note	See Note	ScS will issue the command, capture this data for logging and display. Verify by real-time error reporting of request/command format problems and post-test analysis of logged data.
CD-ER-002	9.2.6.1	Ethernet MDLs/MDL Replacements Connector/ Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.
CD-ER-002	9.2.6.2	Ethernet ISIS Drawers Connector/Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.
CD-ER-004	9.3.1	Analog Signal Characteristics	A	See Note	See Note	ScS supports analog inputs (2 inputs) that can be -5 Vdc to +5 Vdc (balanced/ differential).

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 3 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
CD-ER-004	9.3.2	Analog Driver Characteristics	A	See Note	See Note	ScS supports a demonstration of nominal (electrical) test case for electrical characteristics.
CD-ER-002	9.3.3.1	Analog MDLs/MDL Replacement Connector/ Pin Interface	A&I	See Note	See Note	With the ScS cable set and flight-like connectors, one could close this verification requirement if a demonstration or test is conducted.
CD-ER-002	9.3.3.2	Analog ISIS Drawers Connector/Pin Interface	A&I	See Note	See Note	With the ScS cable set and flight-like connectors, one could close this verification requirement if a demonstration or test is conducted.
CD-ER-005	9.4.1.1	Discrete Output Low Level	A	See Note	See Note	ScS supports a demonstration of the discrete output logic levels.
CD-ER-005	9.4.1.2	Discrete Output High Level	A	See Note	See Note	ScS supports a demonstration of the discrete output logic levels.
CD-ER-005	9.4.1.3	Discrete Output Maximum Fault Current	A	None	None	
CD-ER-005	9.4.1.4	Discrete Input Low Level	A	See Note	See Note	ScS supports a demonstration of the discrete input logic levels.
CD-ER-005	9.4.1.5	Discrete Input High Level	A	See Note	See Note	ScS supports a demonstration of the discrete input logic levels.
CD-ER-005	9.4.1.6	Discrete Input Maximum Fault Current	A	None	None	
CD-ER-006	9.4.2	Discrete Driver and Receiver Characteristics	A	See Note	See Note	ScS supports a demonstration of the discrete input logic levels.
CD-ER-002	9.4.3.1	Discrete MDLs/MDL Replacement Connector/Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 4 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
CD-ER-002	9.4.3.2	Discrete ISIS Drawers Connector/Pin Interface	A&I	See Note	See Note	ScS provides a “flight” cable set.
CD-ER-002	9.5	Continuity Discrete Jumper	A&I	None	None	
CD-ER-002	9.6	Point-to-Point Communications Bus	A&I	N/A	N/A	
CD-ER-007	9.7	Video	A&T	See Note	See Note	
CD-ER-007	9.7.1.1	Video Input Impedance	A&T	None	None	
CD-ER-007	9.7.1.2	Video Sync Tip	A&T	None	None	
CD-ER-007	9.7.1.3	Video Blanking Level	A&T	None	None	
CD-ER-007	9.7.1.4	Video White Reference	A&T	None	None	
CD-ER-002	9.7.3	Video Connector/Pin Interface	A&I	None	None	
SW-ER-001	11.1.1	Payload and General Support Computer	A&I	None	None	
SW-ER-001	11.1.1.2.1	RS-232 Communication Cable (Orbiter PGSC)	A&I	None	None	
SW-ER-001	11.1.1.2.2	RS-422 Communication Cable (Orbiter PGSC)	A&I	None	None	
SW-ER-001	11.1.1.2.3	Power Cables (Orbiter PGSC)	A&I	None	None	
SW-ER-002	11.1.1.3	Software (Orbiter PGSC)	T	None	None	
SW-ER-005	11.1.3	ISS Portable Laptop Computer System	A&T	None	None	

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 5 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
SW-ER-004	11.2.1	EXPRESS Rack PEHB Interface	A&T	None	None	
SW-ER-003	11.2.2	EXPRESS Rack RIC Serial Interface (RS-422)	A&T	See Note	See Note	ScS support test log and display for RS-422 interface.
SW-ER-003, SW-ER-004	11.2.3.1	EXPRESS Header	A&T	See Note	See Note	ScS will process payload generated data and issue commands/data using this header. It captures this data and response data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-003, SW-ER-004	11.2.3.3	EXPRESS Telemetry Header	A&T	See Note	See Note	ScS will process payload generated telemetry data. It captures this data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-003, SW-ER-004	11.2.3.4	Payload Telemetry Packet	A&T	See Note	See Note	ScS will process payload generated packet data. It captures this data (request) for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 6 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
SW-ER-003, SW-ER-004	11.2.3.5	EXPRESS RIC Interface Requests and Responses	A&T	See Note	See Note	ScS will process payload generated packet data. It captures this data (request) for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-003, SW-ER-004, SW-ER-007	11.2.3.5.5	File Transfer	A&T	None	See Note	ScS will process payload generated files. It captures this data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-003, SW-ER-004	11.2.3.6	Payload Health and Status Data	A&T	See Note	See Note	ScS win process payload generated Health and Status Data. It captures this data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-003, SW-ER-004, SW-ER-008	11.2.3.7	EXPRESS Payload Commanding	A&T	See Note	See Note	ScS (Laptop) will issue payload commands. It captures this data and response data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.

TABLE F-I VERIFICATION CROSS-REFERENCE MATRIX FOR THE SUITCASE SIMULATOR (ScS) (Sheet 7 of 7)

VRDS	IDD PARA	REQUIREMENT DESCRIPTION	VERIFICATION METHOD	ScS ROLE		NOTE
				S/W Release 2	S/W Release 3	
SW-ER-004	11.2.4	Laptop CSCI Interfaces	A&T	None	See Note	ScS will process the laptop to/from RIC communications via TCP/IP. It captures this data and response data for logging and display. Real-time error reporting of packet format problems and post-test analysis of logged data allows verification of this requirement.
SW-ER-007	11.2.4.2	Payload-Provided Software/Peripherals	A,T&D	None	See Note	ScS will route messages to the laptop which will route to Payload Application. Verify by real-time and post analysis of logged data.
SW-ER-007	11.2.4.3	EXPRESS Rack Laptop Display Requirements	A,T&D	None	See Note	ScS can support display data from payload and Laptop.
SW-ER-004, SW-ER-007	11.2.4.4A	Laptop Communications	A&T	None	See Note	ScS will route the test and demonstration payload data to the laptop (payload application) via the ScS socket or RIC.
SW-ER-004, SW-ER-007	11.2.4.4C	Payload Application Windsock	A,T&D	None	See Note	ScS will route the test and demonstration payload data to the laptop (payload application) via the ScS socket or RIC.
SW-ER-007	11.2.4.5	File Maintenance	A,T&D	None	See Note	ScS will support test of file maintenance. It captures and logs the file for test analysis.
SW-ER-006	11.3	Software Safety Requirements for Payloads	A	None	None	

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APPENDIX G

HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION

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The following is a tentative list of the requirements which are proposed for crew review as a verification option. Note that shaded areas are not covered by crew review and must be verified per SSP 52000-PVP-ERP.

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 1 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.1	NAR	Portable Item Handles/Grasp Areas/Temporary Stowage Restraints			3.12.6.4	
12.1.1	HF-ER-001	Provide Handles and Restraints			3.12.6.4.1	ME-037
12.1.2	HF-ER-001	Handle Location			3.12.6.4.3	ME-037
12.1.3	HF-ER-001	Handle Dimensions			3.12.6.4.4	ME-037
12.1.4	HF-ER-001	Handle Clearance			3.12.6.4.4	ME-037
12.1.5	NAR	Non-Fixed Handles Design Requirements			3.12.6.4.5	
12.1.5A	HF-ER-001	Non-Fixed Handles Design Requirements			3.12.6.4.5A	ME-037
12.1.5B	HF-ER-001	Non-Fixed Handles Design Requirements			3.12.6.4.5B	ME-037
12.1.5C	HF-ER-001	Non-Fixed Handles Design Requirements			3.12.6.4.5C	ME-037
12.1.6	HF-ER-001	Tether Points			N/A	
12.1.7	HF-ER-001	Captive Parts			3.12.6.3	ME-036
12.1.8	HF-ER-001	Temporary Stowage/Placement			N/A	
12.2	NAR	Strength Requirements			3.12.1	
12.2A	NAR	Strength Requirements			3.12.1A	
12.2A(1)	HF-ER-002	Grip Strength			3.12.1A(1)	ST-005
12.2A(2)	HF-ER-002	Linear Forces			3.12.1A(2)	ST-005
12.2A(3)	HF-ER-002	Torques			3.12.1A(3)	ST-005
12.2B	HF-ER-002	Strength Requirements			3.12.1B	ST-005
12.3	NAR	Body Envelope and Reach Accessibility			3.12.2	
12.3.1	HF-ER-003	Operational Volume			3.12.2.1	
12.3.2	NAR	Accessibility			3.12.2.2	ME-021
12.3.2A	HF-ER-003	Accessibility			3.12.2.2A	ME-021

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 2 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.3.2B	HF-ER-003	Accessibility			3.12.2.2B	ME-021
12.3.3	HF-ER-003	Full Size Range Accommodation			3.12.2.3	ME-006
12.4	NAR	Payload Hardware Mounting			3.12.4.2	
12.4.1	HF-ER-004	Equipment Mounting			3.12.4.2.1	ME-011
12.4.2	HF-ER-005	Drawers and Hinged Panels			3.12.4.2.2	ME-012
12.4.3	HF-ER-006	Alignment			3.12.4.2.5	ME-013
12.4.4	HF-ER-007	Slide-Out Stops			3.12.4.2.6	ME-002
12.4.5	HF-ER-002	Push-Pull Force			3.12.4.2.7	ST-006
12.4.6	HF-ER-008	Access			3.12.4.2.8	ME-042
12.4.6.1	NAR	Covers			3.12.4.2.8.1	ME-007
12.4.6.1A	HF-ER-008	Covers			3.12.4.2.8.1A	ME-007
12.4.6.1B	HF-ER-008	Covers				
12.4.6.1C	HF-ER-008	Covers			3.12.4.2.8.1B	ME-007
12.4.6.2	HF-ER-008	Self-Supporting Covers			3.12.4.2.8.2	ME-007
12.5	HF-ER-011, HF-ER-039	Identification Labeling			3.12.7	ME-057
12.5.1	HF-ER-014	Color			3.12.8	ME-047
12.5.2	HF-ER-015	Fluid Connector Pressure/Flow Indicators			3.12.4.3.4	ME-050
12.5.3	NAR	Coding			3.12.4.3.12	
12.5.3A	HF-ER-006	Coding			3.12.4.3.12A	ME-020
12.5.3B	HF-ER-006	Coding			3.12.4.3.12B	ME-020
12.5.4	HF-ER-023	Pin Identification			3.12.4.3.13	EL-007

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 3 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.6	NAR	Controls and Displays			3.12.5	
12.6.1	HF-ER-017	Controls Spacing Design Requirements			3.12.5.1	ME-030
12.6.2	NAR	Accidental Actuation			3.12.5.2	
12.6.2.1	HF-ER-018	Protective Methods			3.12.5.2.1	
12.6.2.1A	NAR	Protective Methods			3.12.5.2.1A	ME-031
12.6.2.1B	HF-ER-018	Protective Methods			3.12.5.2.1B	ME-031
12.6.2.1C	HF-ER-018	Protective Methods			3.12.5.2.1C	ME-031
12.6.2.1D	HF-ER-018	Protective Methods			3.12.5.2.1D	ME-031
12.6.2.1E	NAR	Protective Methods			3.12.5.2.1E	ME-031
12.6.2.1F	NAR	Protective Methods			3.12.5.2.1F	ME-031
12.6.2.1G	NAR	Protective Methods			3.12.5.2.1G	ME-031
12.6.2.2	HF-ER-017	Noninterference			3.12.5.2.2	ME-030
12.6.2.3	NAR	Dead-Man Controls			3.12.5.2.3	
12.6.2.4	HF-ER-017	Barrier Guards			3.12.5.2.4	ME-030
12.6.2.5	HF-ER-018	Recessed Switch Protection			3.12.5.2.5	ME-031
12.6.2.6	HF-ER-018	Position Indication			3.12.5.2.7	ME-032
12.6.2.7	HF-ER-018	Hidden Controls			3.12.5.2.8	ME-031
12.6.2.8	HF-ER-018	Hand Controllers			3.12.5.2.9	ME-031
12.6.3	NAR	Valve Controls			3.12.5.3	
12.6.3A	HF-ER-019	Valve Controls (Low-Torque Valves)			3.12.5.3A	ME-033
12.6.3B	HF-ER-019	Valve Controls (Intermediate-Torque Valves)			3.12.5.3B	ME-033
12.6.3C	HF-ER-019	Valve Controls (High-Torque Valves)			3.12.5.3C	ME-033

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 4 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.6.3D	HF-ER-019	Valve Controls (Handle Dimensions)			3.12.5.3D	ME-033
12.6.3E	HF-ER-019	Valve Controls (Rotary Valve Controls)			3.12.5.3E	ME-033
12.6.4	HF-ER-020	Toggle Switches			3.12.5.4	ME-034
12.6.5	NAR	Stowage and Equipment Drawers/Trays			3.12.6.2	
12.6.5A	HF-ER-032	Stowage and Equipment Drawers/Trays			3.12.6.2A	ME-027
12.6.5B	HF-ER-032	Stowage and Equipment Drawers/Trays			3.12.6.2B	ME-027
12.6.6	NAR	Audio Devices (Displays)			3.12.9.10	
12.6.6A	HF-ER-021	Audio Devices (Displays)			3.12.9.10A	ME-044
12.6.6B	HF-ER-021	Audio Devices (Displays)			3.12.9.10C	ME-044
12.6.6C	HF-ER-021	Audio Devices (Displays)			3.12.9.10D	ME-044
12.7	NAR	Electrical Connector Design - General			3.12.4.3	
12.7.1	EL-ER-013	Mismatched			3.12.9.1.1	ME-019
12.7.2	HF-ER-023	Connector Protection			3.12.4.3.8	ME-019
12.7.3	EL-ER-012, HF-ER-023	Arc Containment			3.12.4.3.7	EL-026
12.7.4	NAR	Connector Arrangement			3.12.4.3.6	
12.7.4A	HF-ER-024	Connector Arrangement			3.12.4.3.6A	ME-018
12.7.4B	HF-ER-024	Connector Arrangement			3.12.4.3.6B	ME-018
12.7.5	HF-ER-022	One-Handed Operation			3.12.4.3.1	ME-017
12.7.6	NAR	Accessibility			3.12.4.3.2	
12.7.6A	NAR	Mate/Demate			3.12.4.3.2A	
12.7.6A(1)	HF-ER-022	Nominal Operations			3.12.4.3.2A(1)	ME-018
12.7.6A(2)	HF-ER-022	Maintenance Operations			3.12.4.3.2A(2)	ME-018

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 5 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.7.6B	HF-ER-022	Accessibility			3.12.4.3.2B	ME-018
12.7.7	NAR	Ease of Disconnect			3.12.4.3.3	
12.7.7A	HF-ER-022	Ease of Disconnect			3.12.4.3.3A	ME-017
12.7.7B	HF-ER-022	Ease of Disconnect			3.12.4.3.3B	ME-017
12.7.8	HF-ER-022	Self-Locking			3.12.4.3.5	ME-017
12.7.9	HF-ER-023	Connector Shape			3.12.4.3.9	ME-019
12.7.10	HF-ER-015	Fluid and Gas Line Connectors			3.12.4.3.10	FD-001
12.7.11	HF-ER-015	Fluid and Gas Line Connectors Mating			3.12.4.3.10	FD-001
12.7.12	HF-ER-006	Alignment Marks or Guide Pins			3.12.4.3.11, 3.12.4.3.11A	ME-020
12.7.13	HF-ER-024	Orientation			3.12.4.3.14	ME-020
12.8	NAR	Hose/Cable Restraints			3.12.4.3.15	
12.8A	HF-ER-025	Hose/Cable Restraints			3.12.4.3.15A	ME-022
12.8B	HF-ER-025	Hose/Cable Restraints			3.12.4.3.15B	ME-022
12.8C	HF-ER-025	Hose/Cable Restraints			3.12.4.3.15C, 3.12.4.3.15D	ME-022
12.9	NAR	Habitability/Housekeeping			3.12.3, 3.12.3.1	
12.9.1	HF-ER-008	Closures or Covers			3.12.3.1.1	ME-007
12.9.2	NAR	Built-In Control			3.12.3.1.2	
12.9.2A	HF-ER-026	Built-In Control			3.12.3.1.2A	ME-008
12.9.2B	HF-ER-026	Built-In Control			3.12.3.1.2B	ME-008
12.9.3	HF-ER-027	One-Handed Operation			3.12.3.1.5	ME-009

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 6 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.10	HF-ER-028 **TBD#24**	Waste Management				
12.11	HF-ER-029	Mechanical Energy Devices				
12.12	NAR	Fasteners			3.12.4.4	
12.12.1	HF-ER-030	Non-Threaded Fasteners			3.12.4.4.1	ME-023
12.12.2	HF-ER-031	Mounting Bolt/Fastener Spacing			3.12.4.4.2	ME-024
12.12.3	HF-ER-031	Multiple Fasteners			3.12.4.4.4 3.12.4.4.4A	ME-025
12.12.4	HF-ER-031	Captive Fasteners			3.12.4.4.5	ME-026
12.12.5	NAR	Quick Release Fasteners			3.12.4.4.6	
12.12.5A	HF-ER-030	Quick Release Fasteners			3.12.4.4.6A	ME-026
12.12.5B	HF-ER-030	Quick Release Fasteners			3.12.4.4.6B	ME-026
12.12.6	HF-ER-031	Threaded Fasteners			3.12.4.4.7	ME-026
12.12.7	NAR	Over Center Latches			3.12.4.4.8	
12.12.7A	HF-ER-032	Over Center Latches (Non Self-Locking)			3.12.4.4.8A	ME-027
12.12.7B	HF-ER-032	Over Center Latches (Latch Lock)			3.12.4.4.8B	ME-027
12.12.7C	HF-ER-032	Over Center Latches (Latch Handles)			3.12.4.4.8C	ME-027
12.12.8	HF-ER-030	Winghead Fasteners			3.12.4.4.9	ME-026
12.12.9	NAR	Fastener Head Type			3.12.4.4.11	
12.12.9A	HF-ER-031	Fastener Head Type			3.12.4.4.11A	ME-028
12.12.9B	HF-ER-031	Fastener Head Type			3.12.4.4.11B	ME-028
12.12.9C	HF-ER-031	Fastener Head Type			3.12.4.4.11C	ME-028
12.12.10	HF-ER-031	One-Handed Actuation			3.12.4.4.12	ME-029

TABLE G-I HUMAN FACTORS VRDS CANDIDATE LIST NOT REQUIRING ANALYSIS FOR VERIFICATION (Sheet 7 of 7)

IDD RQMT NO.	VRDS NO.	IDD REQUIREMENT TITLE	DATE REVIEWED	ASTRONAUT OFFICE ACCEPTANCE DATE	IRD SECTION 3 RQMT	SSP 57010 VDS NUMBER
12.12.11	HF-ER-031	Accessibility			3.12.4.4.2	ME-024
12.12.12	HF-ER-008	Access Holes			3.12.4.4.14	ME-024
3.4.2.3A	HF-ER-037	Stowage Drawer/Tray Zero “G” Requirements			3.12.6.1A	ME-036
3.4.2.3B	HF-ER-037	Stowage Drawer/Tray Zero “G” Requirements			3.12.6.1B	ME-036
3.4.2.3C	HF-ER-037	Stowage Drawer/Tray Zero “G” Requirements			3.12.3.1C	ME-036
10.2.3	EN-ER-001	Direct Light Sources			3.12.3.4C	ME-043
14.3.3	FP-ER-005	Fire Suppression Port Access			3.10.3.2	ME-055

APPENDIX H

ACOUSTIC NOISE CONTROL PLAN FOR EXPRESS RACK PAYLOADS

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APPENDIX H, ACOUSTIC NOISE CONTROL PLAN

H.1 INTRODUCTION

Acoustic sound levels within habitable crew areas of the Orbiter and module have been a troublesome issue in past flights where experiments often exceeded specified noise requirements. This has led to crewmember complaints of communication difficulty, concentration problems, sleep interference, headaches, and ringing of ears. Excessive noise has also been attributed as the cause of temporary threshold hearing shifts during short missions and, in several cases, permanent hearing loss.

The Acoustic Noise Control Plan herein presents an approach that, if followed, will preclude acoustic noise problems within the ISS. Payload equipment cannot be deemed qualified for flight until it is shown that its nominal (non-failure) operating modes, location, and configuration(s) over its life onboard the ISS will not acoustically degrade the crew living environment of the element in which it resides.

Toward this objective, this document summarizes the acoustic noise criteria inside the ISS modules, suballocation of the overall criteria, requirements for verifying compliance with criteria, and methods that can be implemented in design and management of the payload equipment to control emitted noise.

Since part of the process of verifying compliance with acoustic noise criteria is the development of an EXPRESS Rack Payload-Unique Noise Control Plan, this document also provides an outline and guidelines for developing this plan. Hereafter, the use of “Payload-Unique” will refer to “EXPRESS Rack Payload-Unique.” The EXPRESS Rack Payload-Unique Noise Control Plan will outline the procedures, sequence of events, and design developments that will be taken in order to ensure acoustic noise compliance. The items submitted as sample quieting methods are not intended to limit the payload developer’s possible solution base. This plan requires tailoring specifically to the payload developer’s methods of implementation and hardware characteristics.

H.2 ACOUSTIC NOISE ALLOCATION

ISS acoustic noise requirements have been established for an integrated ISS module. The NC-50 noise curve criteria was selected based upon several considerations, notably the following: hearing acuity, speech intelligibility, habitability, safety, productivity, annoyance, and sleep interference. Reference 1 describes the findings that were mandated as NASA’s requirements for acoustics onboard the ISS.

Since total acoustic noise environments in an ISS module is the sum of all noise contributors, the NC-50 noise criteria must be suballocated to the noise-making components within the ISS module. Subsections below discuss suballocation of the module noise criteria to individual racks, to components in a rack, and to non-rack components.

H.2.1 Integrated Rack Allocation

The NC-50 noise criteria, applicable to an ISS module, has been allocated in Section 3.12.3.3 of the Pressurized Payloads IRD (Reference 2) to individual components in the module (e.g., integrated rack). This suballocation of the acoustic noise environment to each integrated rack shall be instituted as design requirements and shall apply to the composite noise level of the noisiest configuration of simultaneously-operating components within the rack (including any supporting adjunct active portable equipment operated outside the integrated rack but within the ISS module).

Acoustic noise limits are defined in Reference 2 for two types of noise sources: (1) Continuous Noise Source and (2) Intermittent Noise Source. To reiterate the definitions, an integrated rack that operates for more than eight hours in a 24 hour period and generates an A-weighted SPL equal to or in excess of 37 dBA measured at 0.6 meter distance from the noisiest part of the rack is a continuous noise source. An integrated rack which operates for less than eight hours in any one 24 hour period and generates an A-weighted SPL equal to or in excess of 37 dBA measured at 0.6 meter distance from the noisiest part of the rack, is an intermittent noise source. Further information is given in Section 3.12.3.3 of the IRD concerning acoustic noise limits for hardware that exhibits both continuous and intermittent noise characteristics.

H.2.2 Subrack Allocation

Acoustic noise limits, provided in Section 3.12.3.3 of the IRD for individual integrated racks, have been further suballocated to EXPRESS Rack payloads in Section 4.7.2 of the EXPRESS Rack Payloads IDD (Reference 3) such that the acoustic noise of the composite rack will not exceed limits defined in the IRD. For payloads with multiple units, these acoustic noise limits shall be further suballocated to payload units by the payload developer such that the acoustic noise of the total payload does not exceed limits defined in the IDD.

H.2.3 Non-Rack Allocation

Acoustic noise limits of non-rack components, operated independently of and outside the integrated rack, are allocated the same limits imposed for an integrated rack. (Reference Section 4.7.2 of the IDD) Note that any external adjunct equipment that is operated in support of a payload is considered part of the payload for acoustic compliance.

H.3 ACOUSTIC NOISE VERIFICATION

Acoustic noise verification of ISS Payloads is a multi-stage process, with data deliveries required at specific points along the path. Section D.3.1 discusses the four primary verification stages. Three of these stages require inputs to the EXPRESS Rack Integrator. Section H.3.2 delineates the verification data required and the schedule for submittal. Section H.3.3 provides additional technical details about the verification data required.

H.3.1 Verification Stages

The first stage of the verification process begins at the start of hardware design development. Many times, acoustic noise compatibility is not addressed by hardware developers until the certification-testing phase (i.e., final verification stage). This is likely to result in hardware that will not meet specified acoustic requirements. To preclude this from occurring, acoustic noise criteria should be included in the hardware design specifications. It is inherently easier to design for “low noise” rather than trying to “seal” the noise from entering the crew compartment. No formal data delivery is required for the first stage; however, plans and actions implemented in the first stage are included in the data delivery for the second stage.

The second stage of verification is the development and submittal of a Payload-Unique Acoustic Noise Control Plan for the subrack payload. The Acoustic Noise Control Plan shall provide the PD’s plan for controlling acoustic noise emissions to ensure that final verification requirements are met. The plan shall also describe acoustic noise data that will be submitted for verification and define test methodology that will be used to obtain verification data. Section H.5.0 herein provides guidelines for developing the Payload-Unique Acoustic Noise Control Plan.

The third stage of verification is the development of preliminary acoustic noise emission data. At this stage, the acoustic noise data should represent the best data available that can be obtained analytically via estimation or calculation, obtained from developmental testing, or obtained using measured data from existing hardware. The preliminary data should provide predictions of the noise emitted from the worst-case continuous noise source and from the worst-case intermittent noise source. Preliminary data shall be submitted to the EXPRESS Rack Integrator at L-22 months.

The fourth stage of verification is the submittal of final data for flight certification that acoustic noise verification requirements have been met. Information submitted in the final Acoustic Analysis Report defines acoustic noise sources, summarizes the acoustic noise emission from the subrack payload (or adjunct equipment), describes tests performed to measure acoustic noise emissions, and documents compatibility with acoustic requirements. Section H.3.2.3 herein provides additional details about contents and schedules for the final

Acoustic Analysis Report. Section H.3.3 provides information concerning technical requirements for the final verification data.

H.3.2 Verification Data Requirements/Schedule

Acoustic data submittals are required for three of the four verification stages discussed in Section H.3.1. Sections H.3.2.1 through H.3.2.3 discuss the data requirements and schedules for each of the three submittals.

H.3.2.1 Payload-Unique Acoustic Noise Control Plan Submittal

The first report that must be submitted is a Payload-Unique Acoustic Noise Control Plan, required 24 months prior to launch. The Payload-Unique Acoustic Noise Control Plan defines the PD's (or adjunct equipment supplier's) plan for ensuring/verifying that the subrack payload or adjunct equipment will meet acoustic noise requirements specified in the IDD. The plan should describe the acoustic noise system, define applicable requirements, describe testing methodology, etc.

The plan should also identify the process that will be used to control the emitted acoustic noise of the payload. This includes a recovery plan (see paragraph H.5.1.5 for details) that will be implemented if acoustic noise emissions exceed allocated noise requirements.

Section H.5 provides more specific details about the development of a Payload-Unique Acoustic Noise Control Plan.

H.3.2.2 Preliminary Acoustic Analysis Data

The second data item that must be submitted is preliminary acoustic noise data at L-22 months. Preliminary data shall include noise emitted from the worst-case continuous noise source and from the worst-case intermittent noise source. Data for continuous-type noise sources shall be SPL data as a function of the octave-band frequencies: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. Linear overall and A-weighted overall levels, and SPL data for the preliminary report are usually obtained from the best source available and may be obtained from developmental testing, previous testing of similar hardware, or from analysis.

The preliminary data submittals provide input to an integrated rack assessment which provides a preliminary acoustic compatibility assessment of whether the integrated rack meets the IRD noise requirements. The integrated rack data will then be used by the Element Integrator to perform a preliminary acoustic noise analysis of the integrated module.

It is important that the preliminary acoustic noise data accurately represents best-available noise level predictions, even if these levels indicate that noise limits will be exceeded. An exceedance will alert the Rack Integrator to a potential problem. Then the Rack Integrator can use information from the preliminary acoustic analysis data to identify, review, and research possible noise reduction measures. The information also can be used to prevent co-location of noisy equipment, thus reducing noise source concentration.

If the preliminary acoustic noise data suggests that acoustic noise limits specified by the IDD will be exceeded, a recovery plan shall be included with the preliminary data submittal. Reference to a recovery plan in the Payload-Unique Noise Control Plan could be used to satisfy this.

H.3.2.3 Final Acoustic Verification Report

The third report that must be submitted, required 11.5 months prior to launch, is the Final Acoustic Verification Report. This report will (1) verify that the payload meets specified acoustic requirements in the IDD and (2) provide data that can be used by the Rack Integrator to perform a final acoustic noise analysis of the integrated rack.

The Final Acoustic Verification Report should identify significant noise sources by type of noise (continuous or intermittent) and provide SPL data for each noise source, noise type and operational mode. Operational timelines for each significant noise source shall be provided in the report. A list shall also be provided identifying independently-operated equipment, dependent hardware, and adjunct hardware.

The Final Acoustic Verification Report shall include the following information about the acoustic testing process:

A. Test Set-Up/Test Room Characteristics- Describe (preferably via sketches) the test set-up including the type of room used in performing the tests. If a “quiet room” is used, document the test set-up/test room characteristics. (“quiet” room is defined in Section H.3.3.1.1) This should include a description of the test configuration (including room dimensions, description of room surfaces, and test article layout), equipment location, and microphone location.

B. Acoustic Noise Emission Data- SPL data shall be provided for the loudest point on each side of the payload element. This information shall be provided for each operational mode for which acoustic sources shall be SPL data measured at the octave-band frequencies: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. The linear overall and A-weighted overall readings should also be provided. Data for intermittent noise sources shall be the A-weighted overall readings. Sound Power Level (PWL) data, as described in Section H.3.3.2, shall also be provided.

C. Background Noise Measurement Data- Background noise measurement data corresponding to the acoustic noise measurements from Item 2 above shall be provided.

H.3.3 Technical Requirements for Verification Data

The objective of acoustic noise testing is to determine the noise emission characteristics of an EXPRESS Rack payload during all on-orbit operational phases. The integrity of the test is highly dependent upon the quality of the acoustic test conducted. An improperly-performed test provides little-or-no useful data that can be used to determine the integrated rack and integrated module acoustic noise environment. The purpose of this section is to provide technical guidelines for performing acoustic emission testing.

SPL tests provide the standard data required for verification. For EXPRESS Rack payloads, however, PWL test data is also required. The data is needed for input to the integrated EXPRESS Rack acoustic analysis. Technical guidelines are given below for both SPL and PWL testing.

H.3.3.1 Sound Pressure Level Testing

H.3.3.1.1 Test Room Requirements

Acoustic noise emission tests shall be performed either in an anechoic or a qualified reverberant quiet room. A quiet room has a background acoustic noise environment at lease 3 dB lower than the test article. A qualified reverberant room is one in which the reverberant characteristics are known.

If a quiet room is selected as the test room, it should have as little background noise as possible. The background noise should preferably be at least 15 dB below the noise limit specified for the test article (i.e., limits discussed in Section 2 herein). If this cannot be attained, the equipment to be measured should emit at least 3 dB greater noise than the background noise levels. If this condition cannot be achieved, it is acceptable if the test article noise levels plus the background noise levels are below the maximum allowable values provided in the acoustical specification. Otherwise, the flight equipment noise is not measurable. For many laboratory environments, additional measures to reduce the background noise will probably be required, such as turning off air conditioning equipment and/or using sound absorbing partitions to create a better background environment. The background noise restrictions apply in all octave bands.

Room dimensions should be as large as possible and the inner surfaces of the walls, floor, and ceiling should be as acoustically absorbent as possible. The width of the room should be at least six meters and in all cases at least four meters. Acoustically reflective articles (e.g., bookcases, tables, and filing cabinets) should be removed from the room or placed at lease three meters from the test article.

GSE that produces noise should be well separated from the flight hardware during the test (preferably located outside the test facility). If the GSE is in the test area, it should be operating during the background noise measurements.

H.3.3.1.2 Test Operation

To obtain accurate and meaningful data, acoustic noise emission tests shall be performed with the test article configured and operating in all operational modes that will occur on-orbit and that result in significant noise emission. Also, operating voltage should be the same as on-orbit.

The test article should be placed on a small table or stand (about one meter high) near the center (but not exactly in the center) of the test room. It should be oriented so that the test article surface is flush with the edge of the test stand and not parallel with any of the room walls.

The first test to be performed is to measure and record the background noise. This will verify that the background noise requirements of Section 3.3.1.1 are met. Background noise data shall be measured in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

After verifying adequate background levels, the following sequence of tests should be performed to measure acoustic noise emission. These tests shall be performed using a Type I Sound Level Meter (SLM) that has been calibrated within the previous 12 months.

A. With the test article operating in a to-be-flown configuration, measure A-weighted overall acoustic emission around all outer surfaces (about 0.6 meter from the surface) to locate the noisiest point on each surface.

B. Record acoustic noise emission from the noisiest point on each surface at 0.6 meter from the surface. If the noise source is continuous-type, SPL data shall be recorded in each of eight octave bands: 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. This data will be used for variant rack configuration analyses. Verification of each payload (or adjunct equipment) is based upon the noisiest location. This data should be measured using linear (no weighting or filtering) response. If the noise source is intermittent-type, only the A-weighted overall data is required.

C. After completion of Step 2, switch the test article off and record the background noise with the SLM ranged at the same full-scale settings used in Step 2. It is not necessary that these background noise measurements be accurate, but are performed to determine how much electronic and acoustic background exist at the settings used when making measurements of the test article.

H.3.3.2 Sound Power Level Testing

PWL testing, performed to determine the strength of the sound source, can be performed using one of several methods, including:

A. Reverberation Chamber Testing

B. Anachoic Chamber Testing

C. Sound Intensity Testing

In general, sound power testing is more involved than sound pressure testing. For example, sound power testing requires numerous measurements from microphones at predetermined locations on an imaginary “test surface” located away from but surrounding the sound source. Requirements for test surface location and number of microphones vary for each method. Therefore, each of the three methods and their associated test surface requirements will be discussed separately. The decision as to hardware, cost, and degree of difficulty in conducting the test.

Discussion of each method includes a brief description of the method, a brief summary of requirements/guidelines, and a list of references that provide additional details for the test method.

In addition to references that apply specifically to one of the three test methods, other references of general interest include References 5 through 8. Note that Reference 5, Chapter 6 describes analytical aspects of PWL measurements.

H.3.3.2.1 Reverberation Chamber Testing

A reverberation chamber (generally a laboratory-grade reverberant room) is characterized as a room where all boundaries are hard and the reverberant sound field extends over nearly the entire room volume. The room shape should meet specified requirements and the total room volume required is determined by minimum third-octave center-frequency to be measured.

Testing can be performed either of two ways: (1) by the comparison method where the test article noise is compared to a reference source (i.e., calibrated power level noise source) or (2) by the absolute method where the sound-absorbing properties of the test room, measured for each frequency band, are used to determine sound power.

Definition of the test surface and measurement locations on the surface is a function of test room volume, wavelength of the sound, and accuracy desired.

Since the reverberation method is based on the premise that a diffuse (reverberant) sound field is present, sound directivity is not an issue. This results in an advantage for the reverberation chamber test method, namely that fewer microphone measurements are required. Thus, use of a reverberation chamber is the quickest method of obtaining sound power level data.

References 5 and 9 through 11 provide additional information about sound power testing in reverberation rooms.

H.3.3.2.2 Anechoic Chamber Testing

An anechoic chamber is characterized as a room where boundaries are highly absorbent and the free-field region (i.e., region free of reverberation) extends almost to the absorbent boundary. The chamber is a semi-anechoic room if the floor is hard and other surfaces are highly absorbent. This is referred to as hemispherical space. The chamber is an anechoic room if all surfaces are highly absorbent.

The test surface is a hemisphere or sphere centered on the noise source. The number and location of measurement points needed depend on the accuracy required and the directivity characteristics of the noise.

An advantage of the anechoic chamber test method is that a more complete definition of the noise emission field can be obtained that includes both sound power and sound directivity characteristics. As an example, sound directivity data can be used to characterize noise emissions from a payload item where the noise emitted from the sides differs from that emitted from the front.

References 5 and 12 provide additional information about sound testing in anechoic and semi-anechoic rooms.

H.3.3.2.3 Sound Intensity Testing

Sound intensity measurements are performed using a sound intensity probe that measures sound pressure at two points separated by a small distance. The sound intensity probe consists of two microphones separated by a spacer, where spacer thickness is determined by frequency range of the noise measurements.

The test surface can be a box, a hemisphere, or a shape that approximates the shape of the test article.

Advantages of the sound intensity test method are that (1) background noise does not affect the total sound power measurement and (2) knowledge of the acoustic properties of the test room is not necessary.

Reference 5, 13, and 14 provide additional information about sound intensity testing.

H.4 ACOUSTIC NOISE CONTROL

Acoustic noise systems can be described as consisting of four components – sources, transmission, paths, and receivers. Since receivers consist of the crew and other payloads, control of acoustic noise must be implemented for the sources and transmission paths. Furthermore, reduction of noise levels at the source is generally the preferred method of noise control with treatment of transmission paths considered a secondary method. Controls are best implemented via design and operational management applied at the beginning of hardware development. Due to weight and space constraints, the easiest manner of developing quiet hardware requires selecting and designing with quiet operation in mind. It is inherently easier to design quiet payloads rather than cover and seal the noise away from the crew environment. Specific suggestions for accomplishing noise control via hardware design and operational control are given below. (See Reference 4 for additional details.)

H.4.1 Hardware Design Technique for Noise Control

H.4.1.1 Control of Acoustic Noise Sources

Mechanical systems involving moving parts (e.g., motors, pumps, fans) or fluid flow systems are usual sources for acoustic noise generation. Thus, noise emission from these sources can be reduced through judicious selection of components and the proper design of fluid systems.

H.4.1.1.1 Selection of Low-Noise-Level Components

Motors, pumps, and fans should be purchased from vendors that certify the balance grade and noise criterion of their equipment. These components should include proper balancing and use of precision bearings. Also, rotating equipment should be used instead of reciprocating equipment.

Equipment items that have multiple operating speeds should be selected. Furthermore, they should be controllable through use of speed controllers, rpm monitoring, or thermally-activated speed control.

Ventilation fans should be selected based on the number of blades and operating speed to avoid resonance excitation in fan support structures. A larger number of blades will create higher excitation frequencies which are easier to control. In general, centrifugal fans with airfoil blades create lower acoustic levels than other fan wheel designs. Also, fan blades constructed from plastic material have been observed to be less noisy than those made of metal.

Alignment functions and power transmissions are often controlled by the meshing of gears or use of chains. Alternate, quieter methods of motion and power transmission can be designed, using various types of belts.

H.4.1.1.2 Fluid System Design for Low Noise

In addition to the selection of low-noise-source components such as motors, pumps, and fans discussed in the previous section, acoustic noise emission from fluid systems can be reduced by designing fluid systems that have low flow velocities and by avoiding large pressure drops in fluid or gas systems.

Use multiple speed pumps to control fluid flow instead of throttling. Throttling tends to induce greater flow noise.

Specify fans that operate in their optimum range and application. (i.e., Do not use a fan designed to move high flow rates through small avionics areas when there is an open plenum area that would allow use of a larger diameter fan turning at much lower speeds.)

Locate fans away from surface panels. This allows the use of duct muffling devices that can absorb noise without affecting flow or delta-P. Also, a fan located near the surface can cause turbulent air currents which, passing through a screen, may cause greater noise that the fan itself.

Other design options for reducing the transmission of acoustic noise from fluid systems are discussed below in Section H.4.1.3.

H.4.1.2 Control of Noise Transmission

Two types of acoustic noise transmission occur: structureborne and airborne. Complex situations may arise where airborne noise is propagated by structureborne vibration and re-radiated into an airspace. Control of this situation involves both attenuating the structureborne transmission path and minimizing structural radiation efficiency.

H.4.1.2.1 Control of Structureborne Noise Transmission

The first order of reducing structureborne acoustic noise transmission is to isolate noise-source components and any associated piping or ducting from their structural support. The second most important item is to design resonant-free support structures by modifying structural stiffness, resonances, damping, and structural coupling. Problem resonances can appear in the form of local panel vibration modes, piping or ductwork vibration modes, or primary structure vibration modes. Primary structure vibration modes are defined as resonances that involve motion of a major portion of the primary support structure. Panel and piping/ductwork vibration modes generally involve motion only in local areas.

When problem resonances cannot be avoided, damping treatments may be applied. Damping treatments include resilient mounts between equipment or piping, ductwork and primary structure, or treatment applied to surfaces of structural members. Resilient mounts can be a simple sheet or block of viscoelastic material between equipment or piping/ductwork and its support structure, or they can be more complex isolation mounts. Treatment to structural members, which is especially effective for local panel vibration, can range from simple thin coatings of viscoelastic materials to multilayered constrained layer treatments.

Most damping treatments perform more effectively at higher frequencies. Thus, resonance avoidance design and damping treatments work well together when support structures are designed to shift problem resonance higher in frequency.

H.4.1.2.2 Control of Airborne Noise Transmission

Airborne noise transmission from payloads aboard the ISS can be controlled by enclosing the source, modification of ducts and interior spaces, or moving the source as far as possible from habitable areas.

A properly designed structure to enclose an acoustic source inherently attenuates the acoustic noise transmitted outside the enclosure. Enclosures designed to attenuate acoustic noise should include attention to many details including: stiffener placement, penetrations, enclosure isolation, and interior geometry. Rib-stiffened panels should be used carefully since sound tends to radiate from structural discontinuities in a panel, such as a rib-stiffened interface. Penetrations in enclosures for cables or pipes should be kept to a minimum. Penetrating pipes or cables should be as flexible as possible to avoid creating flanking paths. The enclosure itself should be mechanically isolated from internal noise sources. Enclosure interior surfaces should be ideally be at least a quarter wavelength away from noise-source-surfaces, at the lowest frequency at which attenuation is desired.

Adding absorptive liner materials within an enclosure increases acoustic absorption within the enclosure, thus reducing acoustic energy and noise. Modification to alter the enclosure reverberation characteristics also may be used to reduce acoustic noise.

Airborne acoustic noise via reverberation of noise from structureborne vibration is controlled by minimizing radiation efficiency. This can be accomplished using the avoidance of resonance frequencies and damping treatment methods discussed in Section H.4.1.2.1.

Air ducts can be significant acoustic noise transmission paths. Constructing air ducts with internal absorptive material or silencers can attenuate propagation of noise down the duct. Both upstream and downstream ductwork should be analyzed and treated as appropriate. Airborne noise is also generated at diffusers and grilles. Lowering airflow velocity reduces this effect. High relative airflow velocities should be avoided in mixing zones where airstreams enter regions of relatively still air.

H.4.1.3 Analysis Uncertainty

Analytical methods are available to develop estimates of the acoustic noise emitted. These include acoustic modeling and other analytical equations that calculate noise from a sound power level source based on absorption of sound, reverberant characteristics, and sound directivity. However, analysis tools are limited to working in the ideal world and there have been many cases where analysis has under-estimated actual levels. Therefore, for acoustic noise analysis in early stages of hardware development or when analysis is used to establish design limits, an error tolerance factor should be applied to the analysis results or acoustic noise specification (±3 dB for example). If the analysis is performed using a test-validated process, a lower error tolerance factor could be applied.

Elimination of analysis uncertainty and the establishment of a successful acoustic noise program require an energetic measurement program. As the design process proceeds from the design phase into fabrication, measured data should be obtained and substituted for estimated or calculated data.

H.4.2 Operational Techniques for Noise Control

H.4.2.1 Operating Parameter Management

Operation of equipment items which have multiple operating speeds (e.g., fans, pumps) can be used to control acoustic noise emission. Control can be applied in two ways: (1) by using worst-case operating characteristics in the noise budget allocation or (2) operate equipment at speeds that minimize noise emission. Operating voltage is usually a significant parameter in the noise emission of fans and rotating equipment. Reducing operating voltage to the minimum level required can significantly reduce noise emission. Also, pumps should not be operated near speeds corresponding to pump shaft resonant frequencies.

Setting cooling devices to less strict temperature limits can also be used to abate noise emission. Limits that are more strict than needed causes extra duty cycles of operation.

H.4.2.2 Equipment Location

Provide physical separation of noisy hardware items that must operate concurrently. Since a portion of the emitted acoustic noise is a function of distance from the source, will reduce the noise environment at a given point.

H.5 GUIDELINES FOR DEVELOPMENT OF A PAYLOAD-UNIQUE NOISE CONTROL PLAN

As defined in Section H.3.2.1, the payload developer is required to develop and submit a Payload-Unique Acoustic Noise Control Plan. Guidelines are provided in the following subsections for development of the information required in the plan. This includes defining the technical contents of a typical plan and defining the approval process.

H.5.1 Technical Content

The plan should define the approach that the payload developer will take to ensure/verify that the payload meets specified acoustic noise requirements. In general, the plan will describe the system in terms of various noise sources, define applicable requirements, describe how verification data will be obtained, describe how the data will be documented, and describe the general process for controlling noise.

H.5.1.1 System Description

The acoustic system(s) that are covered by the plan should be described. The system description should define the sub-elements comprising the acoustic system and define who is responsible for providing acoustic data for the final verification of each sub-element. Description of the acoustic system also should define the type of noise emitted for the sub-element hardware (i.e., continuous, intermittent). The system description should define the hardware system configuration. Figures should be provided if possible, particularly for multi-element payload systems.

H.5.1.2 Requirements Definitions

A Payload-Unique Acoustic Noise Control Plan should define the applicable acoustic noise environment that will be used as limits in hardware design/development and imposed as verification requirements. These noise limits include the applicable environments from the EXPRESS Rack Payload’s IDD.

H.5.1.3 Description of Test Methods

The Payload-Unique Acoustic Noise Control Plan should describe the acoustic testing process. The description should include:

A. Description of test facility. Includes type of facility (e.g., anechoic, quiet room), dimensions of test room, and acoustic properties of test room. (If test facility information is unknown, a description of the requirements that will be levied for the test facility can be described in lieu of the test facility description.)

B. Identification of acoustic noise measuring devices. This includes a definition of acoustic noise measuring equipment that will be used for tests (or a description of requirements that will be levied).

C. Description of test article configuration. This should define all of the on-orbit configurations for the test article(s) that generate significant noise, identify which of the configurations will be tested, and provide rationale or selection process if not all are selected for test.

D. Summary of the Acoustic Noise Test Plan/Procedure. This should provide the basic approach of how testing will be performed, where measurements will be made, and a description of the data that will be measured.

H.5.1.4 Reporting Process

To ensure that preliminary and final acoustic noise data will meet the needs of the Rack Integrator, the Payload-Unique Verification Plan should include a description and format of data that will be included in the Acoustic Noise Verification Report.

H.5.1.5 Noise Control Process

The Payload-Unique Verification Plan should describe the basic process that will be used for controlling acoustic noise emission. This includes controls placed on hardware development, such as plans for incorporation of acoustic noise criteria in hardware specifications. Also, controllable design and operational factors such as those defined in Section H.4 herein are other examples.

Another aspect of the Acoustic Noise Control Plan is the payload developer's recovery plan if acoustic noise emissions exceed specified limits. The recovery plan should include the case where preliminary analysis results predict that specified limits may be exceeded and the case where final verification shows exceedance of specified limits.

The following are typical examples of steps that could be implemented and described in a recovery plan.

A. Modify Equipment to Reduce Acoustic Noise Emitted – Discuss possible equipment design modifications that could be implemented to reduce noise.

B. Change Equipment Operational Parameters – Examples include change of equipment operating speed, change in operating voltage, etc.

C. Remove Conservatism using Higher – Fidelity Data – If acoustic noise data is preliminary data incorporating a factor of safety, an early energetic testing program can remove unnecessary conservatism, thus reducing the predicted noise emission.

H.5.2 Approval Process

The Payload-Unique Acoustic Noise Control Plan shall be submitted to the EXPRESS Rack Integrator per the schedule in Section H.3.2.1 herein. It is reviewed by the EXPRESS Rack Integrator Team to verify that the planned acoustic noise control and verification plans are adequate to meet specified noise requirements of the IDD and the data needs of the Rack Integrator. Review comments/approval will be returned to the developer of the plan within two months after plan submission.

H.6 REFERENCES

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